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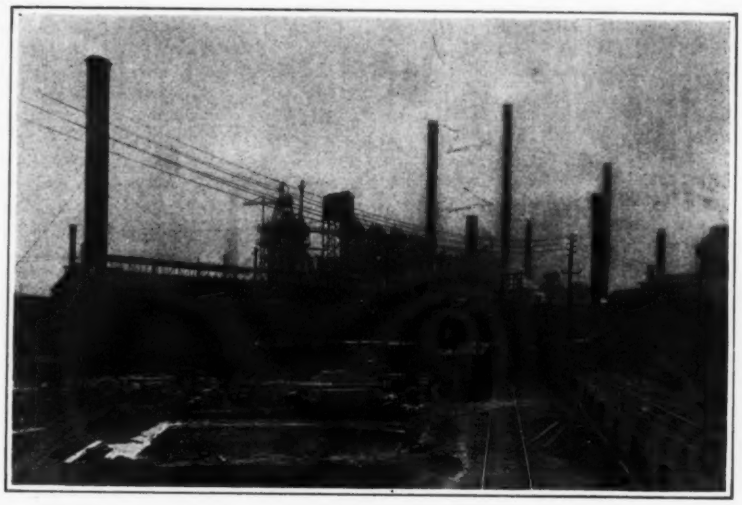
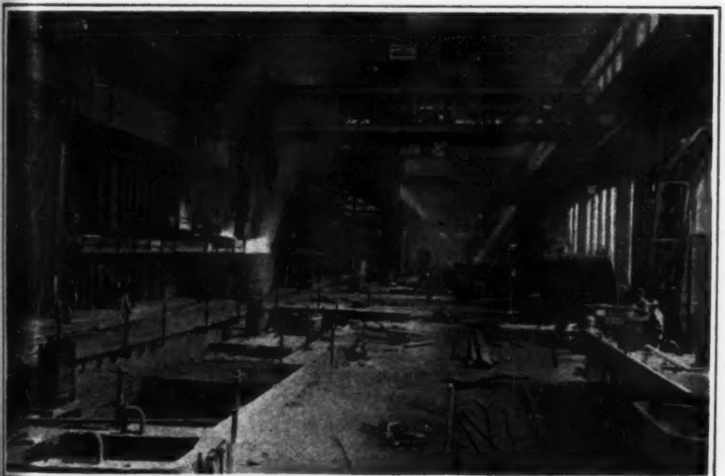
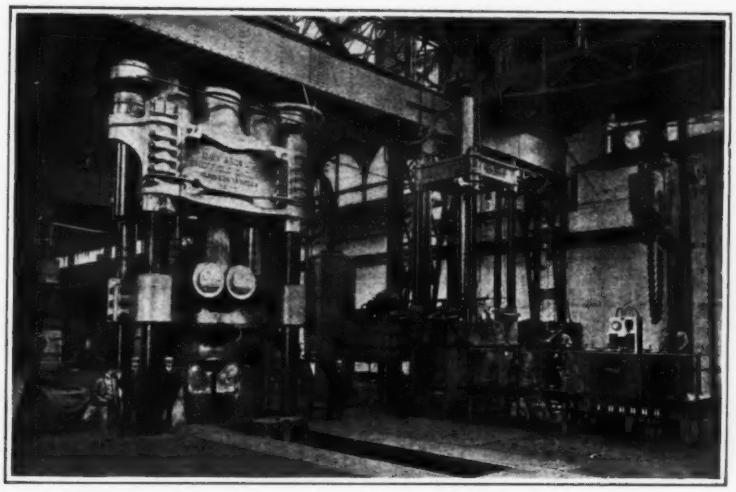
The Sophia works.



The Witkowitz coke ovens.



Among the Siemens-Martin furnaces.



Forty-five hundred ton forging press.

In the yard of the bridge and boiler works.

Loading crane at the sheet iron works.

AN IMPORTANT AUSTRIAN MINING AND IRON WORKS.—[See page 360.]

Improvements in Radiotelegraphy and Radiotelephony—II*

A Review of Some Recent Patents

By W. H. Eccles, D.Sc.

Continued from Scientific American Supplement No. 2004, Page 347, May 30, 1914

In a patent granted to E. Girardeau, No. 11,703, 1912, there is described a method of exciting oscillations of a single frequency in a secondary circuit comprising inductance and capacity. This is said to be effected by

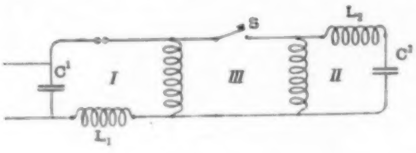


Fig. 11.

linking the primary to the secondary by means of an intermediate circuit containing inductance but possessing negligible capacity. One mode of effecting this is shown diagrammatically in Fig. 11. Here I is the primary, II is the secondary and III is the intermediate linking circuit. The single frequency of the whole system is given by the formula,

$$\omega = \Omega/\sqrt{1-k_1^2-k_2^2},$$

where k_1 is the coupling between circuit I, and circuit II k_2 is that between circuit II and circuit III. In the diagram, S is a "tuning switch;" when it is open, the circuits can be separately adjusted to the same frequency. It is essential that circuits I and II shall have no inductive influence on each other. It is stated that this method of indirect excitation renders it possible to produce a single wave with couplings as close as may be desired—that is to say, in very favorable conditions of efficiency. Although the general theorem implied in the last statement has not yet been proved or disproved from the theoretical standpoint, there is good theoretical reason for supposing that single-frequency oscillations might be obtained by such devices as this, and actual practice appears to support the claim of the inventor.

The *Compagnie Générale Radiotélégraphique* describes in No. 29,375, 1912, a new method of charging two batteries or condensers in parallel and discharging them in series. The advantage accruing from this process has led to many former proposals of means for effecting it, most of them depending on the arrangement and rearrangement of the condenser connections by means of switches. Also it has been proposed to discharge the condensers of two circuits of different periods across the same gap in such a way that when the phases of the currents become opposite the circuits discharge in series. But in the present invention the one condenser remains fully charged until the other has reversed its polarity by discharge, and thus the condensers are connected in series with practically their full charge. Fig. 12 shows a method of carrying out the method. The two condensers cd, approximately equal, are charged from the direct-current or alternating-current mains vv through resistances w. Spark-gaps fg and inductance coils st are arranged as shown, s being coupled with the antenna, the inductance of t being greater than that of s. Imagine that the voltage rises till the gap f breaks down. Condenser c discharges and d cannot; but when c has by discharge reversed its voltage there exists practically double voltage in circuit $csdg$ and the gap g breaks down. It is stated that a more practical form of the apparatus is got by replacing the spark-gap f by a mercury lamp, thus taking advantage of the remarkable quenching powers of the mercury vapor lamp. In this case the action is a little different and is worth notice. In Fig. 13, the coil u in series with condenser c is very small compared with coil s in series with condenser d, and therefore c discharges more quickly than d. The mercury lamp q is provided with a starting terminal, z, energized by the inductorium i. Initially condensers cd are charged, and when the inductorium lights the lamp c begins its discharge and performs half a swing in a time so short that d loses little charge. At the moment c becomes fully charged with reversed sign, the current through the lamp vanishes, the lamp is extinguished, and both condensers now discharge in series in the circuit $cusd$. The lighting of the lamp may be accomplished by a rotating commutator, so that a musical note is produced for signaling.

W. Torikata, E. Yokoyama and M. Kitamura have obtained protection for improvements in spark- (or arc?) gaps for use in radiotelephony or telegraphy. In No. 10,823, 1912, it is stated that if one or both of the electrodes of a spark-gap be replaced by such materials as silicon, ferro-silicon, carborundum, boron, and minerals such as graphite, meteoric iron, magnetite, iron pyrites, copper pyrites, bornite, molybdenite, etc., and if the gap length be shortened till the terminals "practically touch," then oscillations similar to those produced by a quenched

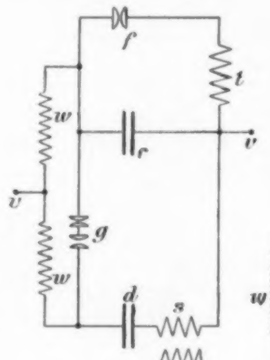


Fig. 12.

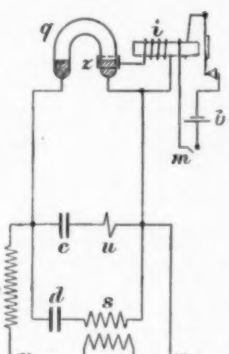


Fig. 13.

spark are generated in an inductance-capacity shunt circuit. The inventors state that they do not know precisely whether the discharge is an arc or a quenched spark, but the spark frequency is well above the audible limit. They say that a semi-insulating film appears to be formed between the electrodes by the first discharge, which prevents the gap from becoming short-circuited, though not preventing discharges.

It will be noticed that the substances named above as suitable for electrodes are all among those used in making

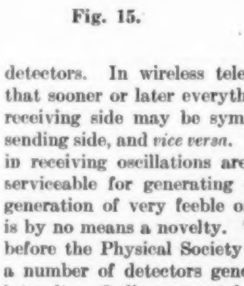


Fig. 15.

Fig. 16a.

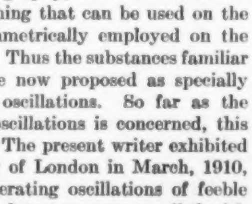


Fig. 16b.

detectors. In wireless telegraphy, it seems inevitable that sooner or later everything that can be used on the receiving side may be symmetrically employed on the sending side, and *vice versa*. Thus the substances familiar in receiving oscillations are now proposed as specially serviceable for generating oscillations. So far as the generation of very feeble oscillations is concerned, this is by no means a novelty. The present writer exhibited before the Physical Society of London in March, 1910, a number of detectors generating oscillations of feeble intensity. Ordinary crystal detectors were supplied with the small currents with which they are usually used, while

Fig. 17a.

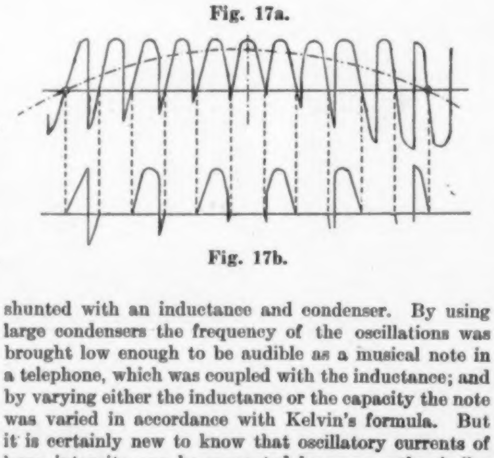


Fig. 17b.

shunted with an inductance and condenser. By using large condensers the frequency of the oscillations was brought low enough to be audible as a musical note in a telephone, which was coupled with the inductance; and by varying either the inductance or the capacity the note was varied in accordance with Kelvin's formula. But it is certainly new to know that oscillatory currents of large intensity can be generated by apparently similar means. In the case of the feeble oscillations generated by detectors, the explanation given by the writer rested on the fact that the substance used as electrodes possessed negative temperature-coefficients of resistivity. In the case of strong oscillations generated as described in this

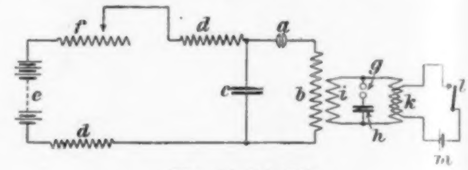


Fig. 14 (16,827).

specification, the explanation may probably be quite different—it may even depend, for example, on "Trevelyan rocker" action.

A. Shaw describes in No. 18,111, 1912, a form of spark-gap which is capable of giving discharges following each other at a very high rate. The electrode is merely a flat metal plate, confronting a metal cone pierced with a central hole. Through this hole a blast of air or other gas is driven so as to impinge squarely on the center of the flat electrode. The discharger is used in a circuit coupled to an antenna in a manner appropriate for shock excitation, and the frequency ot the exciting circuit is, it is stated, higher than that of the antenna. Moreover, the capacity in the exciting circuit is so proportioned that the condenser charges and discharges once in every half cycle of the primary circuit. Some interesting practical details are given. The electrodes are best made of copper or silver—zinc shows a tendency to pit at the place of impact of the gas jet. The diameter of the gas jet is greater the greater the power of the transmitter, being about 1/64-inch for a 2-kilowatt set. The pressure should be about 110 pounds per square inch on the average, being a little more or less for voltages higher or lower than about 28,000 volts. If the pressure is increased to 150 pounds per square inch, with the voltage named, the blaze assumes another form, and the generation of oscillations is less efficient; while below 50 pounds' pressure per square inch the blast is of little assistance. With correct conditions, when the primary circuit is closed, the discharge consists of a series of unidirectional impulses of extreme rapidity. The patent covers the use of a series of these air-blast dischargers arranged on a revolving disk which carries them past fixed electrodes, and in that way produces a musical note. This blast-discharge is reminiscent of a certain French method.

Another patent concerned with spark-gaps is that of K. Rottgardt, No. 22,875, 1912. Here it is claimed that if the gap be filled with heated iodine vapor the sparks are efficiently quenched, even though the electrodes are a relatively large distance apart.

In specification No. 10,111, 1912, A. E. J. Vlug claims protection for a method of producing musical spark signals by aid of a Wehnelt interrupter. The improved Wehnelt anode consists of a platinum wire 1 millimeter in diameter, covered with insulation, tapering gradually to the end, and immersed in any of the familiar electrolytes; it is used with a transformer which has a very small secondary self-induction, and which is connected to a condenser of as large capacity as possible, provided that the natural frequency of the transformer secondary is not brought below about 350 per second. By this arrangement, it is stated, the spark at the Wehnelt anode is avoided, and thus one of the chief causes of the impracticability of the Wehnelt interrupter removed.

The Gesellschaft für drahtlose Telegraphie show, in No. 16,827, 1912, a method of igniting the gap of a large discharge circuit by means of a small expenditure of energy from an auxiliary circuit. Fig. 14 shows the method excellently. Here the main discharge circuit is formed by the condenser c, the inductance b, and the disk spark-gap a; it is charged from the source of power e through the rheostat f and the choking coil d. To the main oscillatory circuit is linked the auxiliary circuit hig, which is supplied with energy by the cell m through the inductorium ki. When the working gap a is open it forms a condenser of small capacity, and the circuit containing it has, therefore, a high natural frequency—to this frequency the auxiliary circuit hig is preferably tuned. It is stated that by this means the auxiliary energy required for ignition of the working gap a, even when the supply voltage e is well below the disruptive voltage of the gap, is relatively small. The arrangement can be used either

* Reproduced from *The Electrician*.

with ordinary spark gaps or with quenched sparks. In the latter case the quenching is better when an auxiliary ignition device is employed, because of the fact that the supply voltage e is low. It is to be noted also that since the spark frequency is determined by the auxiliary circuit the note of the signals is not changed by alteration of the supply voltage in the working circuit, as must usually happen with ordinary quenched sparks working. Moreover, the Morse key may be placed in the ignition circuit. When working on alternating current, it is advantageous to excite the ignition circuit by the same alternating-current supply with suitable phase displacement of the supply voltage.

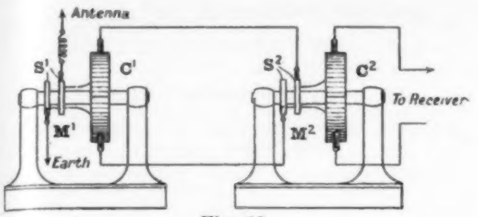


Fig. 18.

A grave disability of the original quenched spark system is partially removed by ignition devices of this type. In quenched spark working there exists for every pair of circuits one or more critical degrees of coupling at which pure shock excitation occurs. These critical couplings are dependent on the length of the spark. When the sparks are very short the wear of the metallic surfaces rather rapidly produces irregularity in the antenna oscillations—e. g., double waves may suddenly appear. By means of auxiliary ignition circuits, much longer gaps may be used than formerly, and the wear of the electrodes thus rendered proportionately more insignificant, which tends to increase the certainty of operation. In fact, with ignition methods, the spark-gap, or series of spark-gaps, does not have to fulfil two functions, quenching and limiting the supply voltage; it only acts as a quenching resistance. It follows again that the strength of the signals transmitted may be varied when desired by varying only the supply voltage to the main circuit, whereas formerly this variation had to be accompanied by a proportionate increase in the number of gaps.

RECEIVING APPARATUS.

Turning to the patents covering apparatus concerned with the receipt of signals, we find a wide range of variety in the principles invoked.

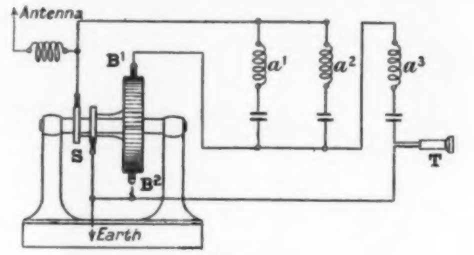


Fig. 19.

R. Goldschmidt is granted patent No. 23,734, 1912, for a method of receiving signals, according to which the high-frequency current is transformed to medium and low frequency by means of an asynchronously rotating commutator or toothed disk. In order to explain the method it is best to start with the ideal case in which a commutator rotates synchronously with the oscillations. In Fig. 15 is shown a two-part commutator provided with slip-rings, so that the antenna and the earth wire are connected to segments 1 and 2 of the commutator. The brushes C and D, when properly adjusted, collect perfectly rectified current when the commutator rotates at synchronous speed, as indicated in Figs. 16A and 16B. Of course, it is very difficult to accomplish this process at the high frequencies of wireless telegraphy, for it is almost impossible to preserve synchronous speed and to maintain continuous accurate adjustment of the brushes. But when the commutator rotates either more slowly or more rapidly than the synchronous speed, the electro motive force at the brushes C, D has a serrated wave form as shown in Fig. 17A, with an overall periodity equal to the primary periodicity multiplied by the ratio: (Synchronous speed—actual speed)/Synchronous speed. The serrations can be largely removed by interposing choking coils or other tuning devices, but the membrane of the telephone will yield a note of the above periodicity without trouble being taken to apply smoothing-out processes. Similar results are achieved if instead of the commutator a toothed wheel and a single brush are used, Fig. 17B.

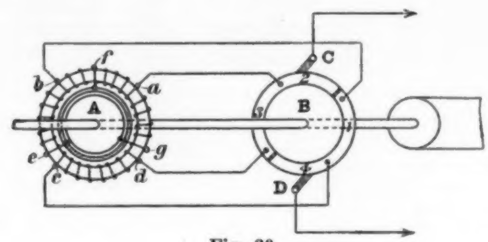


Fig. 20.

When, for mechanical reasons, the transformation cannot be effected by one commutator apparatus, several may be connected in cascade. This is shown in Fig. 18 for two sets of apparatus M_1 and M_2. S_1, S_2 are the slip-rings, C_1, C_2 the commutator-segments. The relative adjustment of the brushes must be very accurately made. Instead of connecting sets of apparatus in cascade, the lower frequency current may be repeatedly returned to the apparatus until the desired low frequency is obtained. In Fig. 19, the current from the antenna is led to slip-rings S at antenna frequency f, is taken from the brushes B_1, B_2, at frequency f_1, and led through the circuit a_1, which resonates at frequency f_1; is passed again through the transformer, reduced to frequency f_2, and led through the circuit a_2, which resonates at frequency f_2; is passed again through the transformer, reduced to frequency f_3 and delivered to the receiver T, whose circuit is tuned to frequency f_3 if desired. The inventor emphasizes the fact that the method he describes may be regarded as a limiting form of certain methods devised (by Leblanc, for instance) in heavy electrical engineering for the purpose of transforming alternating current into direct current and *vice versa*, Fig. 20.

(To be concluded.)

The Rose-Growing Industry of Lyons*

The famous rose gardens of Lyons owe their excellence largely to a light soil, an abundance of sunshine and the proper amount of moisture. From time immemorial, local rose-growers have taken advantage of these favorable conditions until skill and interest in the industry have made the roses of the Rhone valley known throughout the parks and gardens of the world. The ground where the roses are chiefly cultivated is on the outskirts of the city. It is flat, devoid of shade trees and protected only by high walls at the confines of the property. The rose plants are set out for commercial purposes in straight rows, sometimes 100 feet long, the smaller plants 6 inches apart with about 10 inches between rows, while the larger grafted or budded varieties are inserted 10 to 12 inches apart, with 18 inches between rows. The United States Consul at Lyons says that nearly all of the plants are out of doors. The greenhouses for a rose garden of 15 acres do not number more than two, averaging 30 feet in length. It is only in exceptional winters that the plants have to be covered. Sometimes the tops of the older plants are rather loosely bound in straw. In every large commercial rose garden of Lyons hundreds of eglantine rose plants are kept to a single stalk for grafting. These are usually gathered by peasants in the woods, or on uncultivated land, and sold to the rose-growers. Roses grown in the alluvial plain near Lyons thrive often even more luxuriantly when transplanted in a heavier soil; but roses taken from such heavier earth, where they may have been grown exclusively, occasionally retrograde when set out in Lyons. An instance may be cited in the case of the "American Beauty," stated to be originally the "Madame Ferdinand Jamin," a French rose, but developed in America and rechristened there. This rose loses much of its acquired richness and size when set out on the land in Lyons. The common rambler, on the other hand, luxuriates on every trellis and pillar. The standard varieties flourish in the Lyons climate, so that nearly all of the best roses of other countries besides the Lyons varieties are grown by local nurserymen. Those whose sole occupation it is to grow roses on a large scale for profit have been known to bring out many new varieties in a year. The resulting roses, if not like the mother flower, may be diminutive in size and enlarged by grafting, but much of the work is experimental, and most of the new varieties are not found to be sufficiently interesting to perpetuate, so that in the end only a few choice ones of marked individuality are definitely named and presented to the public through the catalogues. Some of the finest roses ever known have been grown within sight of the towers of the ancient city of Lyons. That it often takes a vast amount of patient study to develop a new rose may be gathered from the fact that years may elapse before the final bloom grown from seed is perfected and made ready for the trade through propagation by cuttings or otherwise. When success does come—and it comes often enough to make the effort worth the while of the rose-growers of Lyons—the reward is ample. During the present season an entire stock of 10,000 plants of a new rose of a rare coral tint was sold out as soon as offered.

* *Journal of the Royal Society of Arts.*

South America as an Export Field

In considering the trade possibilities of South America two facts stand out as of prime importance, first, that the continent presents a vast range of thinly populated and undeveloped land, which is apparently on the eve of a great era of exploitation, and second, that almost the whole continent must buy a great part of its supplies of manufactured articles from North America and Europe, and will probably continue to do so indefinitely. The keynote of national life in every country in South America is "development." Although explored and settled long before North America, the continent, with an area of 7,162,000 square miles, has a population of only 49,000,000, half that of the United States, and of these some 8,000,000 are Indians and 3,000,000 negroes. There are untouched resources of every kind of wealth—great expanses of grassy plains for feeding live stock, wide stretches of rich farming land, not only on the level savannahs and selvas, but in the mountainous districts as well, mineral deposits of all kinds in an unknown amount, valuable forests of hardwoods and other kinds of timber, and in almost every section abundant waterfalls for power. All this awaits three factors especially, before it can be utilized—transportation, capital, and workingmen. Under the direction of foreign interests, particularly English and American, railroad building is going forward steadily in nearly all parts; capital, largely English and French, is being drawn from foreign countries as assurances of security are given, while in the south local capital is becoming prominent; but for the third requisite, good workingmen, there is still a wide field open, and the great cry of all the progressive nations is for more able-bodied and intelligent labor. Since the beginning of the twentieth century the advance of South America has been notable in almost every economic line, and although checked occasionally by financial or political crises, droughts, etc., will undoubtedly continue at the same or greater rate in the next few decades as in the last one.

This expansion offers a peculiarly promising market to the manufacturing nations of the world, inasmuch as South America itself provides few of its own needs, except raw food products. In return for the output of its mines, forests, and soil it takes manufactured articles of all descriptions from Europe and North America. Industrial development has made a beginning in Argentina, Chile, and Brazil, and in time will probably rise to a position of considerable importance, as the latter countries have iron ore and excellent water-power facilities, and Chile has, in addition, deposits of coal of unknown extent. But the people of South America as a whole do not take readily to manufacturing, and they will continue for an indefinite period to look to over-sea nations for the bulk of their manufactured goods. This affords a fair field in which North America and Europe can strive for the trade, little checked by local competition, and one, moreover, in which a business once established will tend to grow of itself with the natural expansion of the countries.

Very much of this trade has been in lumber and other products, which have sold without great effort, and it is only in the last four or five years that American exporters have made much of an attempt to study the market seriously. Until recently a great part of the freight and nearly all the passenger traffic between the United States and Brazil and the River Platte went by way of Europe; but nearly all the freight is now sent direct, and the passenger boats which, a few years ago, were said to be running at a loss, have now found it desirable to offer excellently appointed vessels and frequent service. Commercial travelers are beginning to visit South American countries in increasing numbers, information as to markets is more eagerly sought, and there is more inclination to conform to trade requirements than ever before. Trade in recent years has accordingly begun to mount up, and American goods are seen in greater quantities and variety on South American markets. The figures given strikingly show the steady and regular growth in this trade since 1903, in which time there was an increase of over 250 per cent. Considering the advantages, however, of geographical location with reference especially to the north and west coasts, the proportion of the imports supplied by the United States is yet far from what it could be, and as Americans come to concentrate more and more on the market it will be certain to grow substantially.—From *Bulletin* published by the Department of Commerce and Labor.

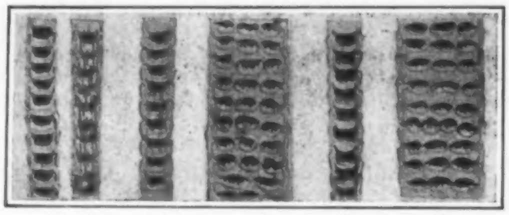


Fig. 1.—A, B, C, D, black mouse; E, F, blue mouse.[1]

A comparison of *C* and *D* with *E* and *F* shows that there is little difference between the pigment content of black and blue hairs. The medullary cells filled with pigment granules may be seen surrounded by canals from which the air has been expelled.

Fig. 2.—White hair from black English rabbit. Magnified 500 times.

Stained with methyl-violet. The air has been partly expelled from the largest hair, showing clearly the stained granular substance or chromogen.

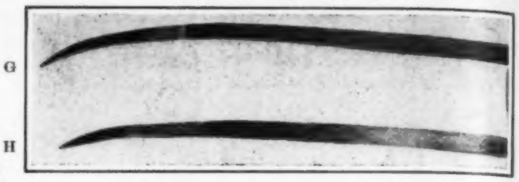


Fig. 3.—Hairs of common wild rabbits.

G shows a diagrammatic sketch of an Agouti hair. *H* shows the same of a steel.

The only portions of the hairs visible when they are lying on the animal are the black and yellow tips.

Hairs and Hair-Pigments[*]

Physical Structure and Chemical Character

By H. Onslow

THE origin of the pigments in the hair of men and animals is a subject that has already received much attention, and there exists a wide but scattered literature concerning it.

In spite of the considerable amount of labor that has been expended, the few conclusions arrived at do not seem to rest on a very firm experimental basis. But the attention that has been devoted to Mendelian analysis has given a fresh motive for the elucidation of this problem, and it has acted as a stimulus to further research.

The coat colors of animals form very distinct characters, and for some years it has been largely the custom to use these characters in Mendelian analysis, since by their means the material to be analyzed can easily be placed in suitable categories. It is on account of this that further knowledge has been sought with regard to the nature and origin of the pigments underlying such coat colors; for the advantage that the science of genetics would gain, if it were able to express hypothetical pairs of allelomorphic characters in terms of another science, such as chemistry, is too obvious to need further comment. As a matter of fact, this has already, to some extent, been accomplished with regard to the pigments of flowers, though not yet to animal pigments.

Although the colors of animals are very distinct to the superficial glance, yet, under chemical and microscopical investigation, the pigments themselves do not seem to differ so widely; the colors tend to shade into one another, and the nature of the chromogens and the enzymes which give rise to the pigments is practically unknown.

STRUCTURE OF THE HAIR.

The structure of the hair is of special importance, for it controls to a considerable degree the macroscopical appearance of the hair, though this has not hitherto been clearly shown to be the case.

A typical hair-shaft is composed of three parts, the medulla, the cortex, and the cuticle. The medulla does not occur in all hairs, but when present consists of a single or multiple column of oval-shaped cells (see Fig. 1, *C* and *D*), generally surrounded by, but sometimes filled with, air. These cells, containing pigment granules, may be seen in Fig. 1, *A* to *F*. Next to the medulla—or, in its absence, occupying the entire shaft—is the cortex, composed of a fibrous substance which is resolvable into very long, pointed cells: these may again be reduced to minute fibrils by the continued action of a hot solution of ammonia under pressure. These fibrils do not, as has been supposed, serve to bind the horn-cells together, but they actually compose the body substance of the cells themselves, and the pigment granules frequently lie within them in single rows. Fig. 1, *A*, shows these rows of granules in the periphery of the hair.

* Reproduced from *Knowledge*.

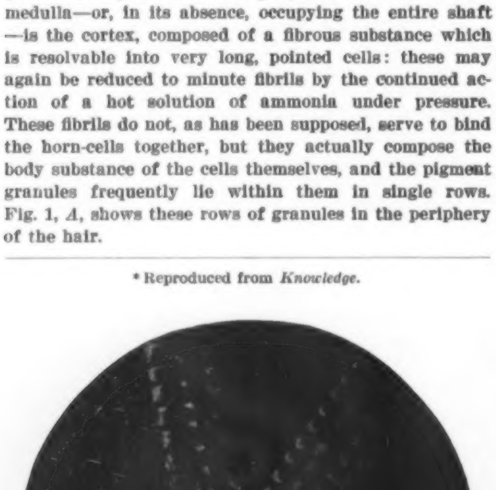


Fig. 4.—Silver-fawn mouse.[2]

Without the cortex is the cuticle, a layer of flat imbricated cells all pointing upward, which cover the entire cortex like the scales of a fish. The interstices between the cells of the medulla, and sometimes of the cortex, are at first filled with a liquid, which often dries up, so that the air can penetrate, and form a regular pattern or network of canals between the cells. This air may be seen between some of the cells of the big hair in Fig. 2. Sometimes the cells themselves are filled with air, so that they swell out and look like small air-bubbles; but it is most usual to find the air present intercellularly.

The air-content or vacuoles show, in many hairs, so regular and homogeneous a pattern, that it is hard to believe that they are due simply to a haphazard shrinkage of the cells, and have no structural signification.

COLOR OF THE HAIR.

The color of human hair depends upon the color and form of the pigment (i. e., whether it is diffused, or deposited in granules) and upon the vacuoles. These vacuoles appear black by transmitted light on account of their optical properties, but by reflected light they become brilliant white points (see Figures 4 and 5). In light and sandy hair the pigment is chiefly diffused, and of a reddish-yellow color, but in darker hair the pigment is present as dark brown or black granules. In the hair of albinos, however, of both fair and dark races, as well as in that of certain red-haired people, there occur practically no granules whatever, but only diffused pigment. When stained, human hair that has gone white with age shows no internal structure, but only a few irregular vacuoles, and, unlike white rabbit hair, becomes a pale color throughout, with no pigment bodies whatever.

HAIR OF ANIMALS.

Among animals also the pigments and air-content are the chief factors that determine the color. But there are so many different types of hair among the vertebrates that this description must necessarily be confined to those domesticated animals which have been mostly used in Mendelian analysis, namely, rats, mice, rabbits, and guinea-pigs. The hairs of these animals resemble each other very closely, since they all have a large intercellular air-content; and the three pigments, black, chocolate, and yellow, are apparently the same in the four species. The guinea-pig presents the greatest difference, since the red or yellow type possesses a certain amount of reddish-yellow pigment diffused throughout the medulla and the cortex, and further its hair shows a very perfect recticular system of air-canals, unlike the more vacuolated appearance of mouse and rabbit hairs.

The colors which have been most studied among these animals are black, chocolate, and yellow, caused respectively by black, chocolate, and yellow pigment, and also the dilute types of these colors, namely, blue, fawn, and cream, which are structural modifications of the intense colors. These dilute colors, as they are called, have been considered to be due only to a greater diffusion and a smaller number of the pigment granules than occur in the intense colors. As a matter of fact, this is not a full statement of the facts. A number of careful observations have shown that the intense colors contain only about 7 per cent more granule groups in a given length than the dilute colors, and the size of the granule groups is only 7 per cent larger in the former than in the latter (see Fig. 1, *A*, *B*, *C*. *D*), while the size of the granules remains the same. It is true, however, that the pigment granules are not deposited so thickly in the light hairs, and that many of the darker hairs contain granules in the periphery as well as in the medulla (see Fig. 1, *A*.). In addition to this, the air-content of the hair plays a very considerable part. Looked at by reflected light (see Figs. 4 and 5), the vacuoles appear larger and more conspicuous in the dilute colors, since they are less obscured by the granules. In the intense colors the granules not only tend to hide the vacuoles, but these are also often so distributed throughout the cortex, and between the granule groups, that they absorb the light before it is reflected by the vacuoles, so that the hair appears black or chocolate, instead of blue or silver-fawn, as it would do if more light were reflected.

Within the cells of the medulla and between each vacuole lie the granule groups, which are, on the average, 72μ broad and 112μ long, composed of oval-shaped granules 1.2μ broad and 1.7μ long. The granules are probably composed, not only of pigment, but also of a ground substance, which may be separated from the pigment by means of alkalies. Inorganic matter is present in this ground substance, possibly as a mordant to the pigment with which it is stained, or possibly as an additional (inorganic) oxydase, which takes part in the oxidation of the chromogen, in the manner of some manganese salts.

In addition to this ground substance, there are, as will be seen later, two other bodies which go to form the pigment, namely, a colorless chromogen and an oxidizing enzyme. The hair of an animal may therefore be colorless for one of three reasons: (1) The absence of either the chromogen or the enzyme; (2) the absence of both chromogen and enzyme; or (3) the presence of an inhibitor of the enzyme. That dominant white flowers, that is to say, white flowers which, in the first genera-

[1] *A* shows the hair with the central portion in focus. *B*, the same hair with the periphery in focus. The pigment granules which absorb the light before it is reflected by the vacuoles may be seen lying in rows within the fibrils. *C* and *D* are normal black hairs from which the air has been expelled by caustic soda.

[2] The views shown in Figs. 4 and 5 are seen by reflected light. The vacuoles appear white, and may be seen more obscured by the structure of the hair in the chocolate mouse than in the silver-fawn.

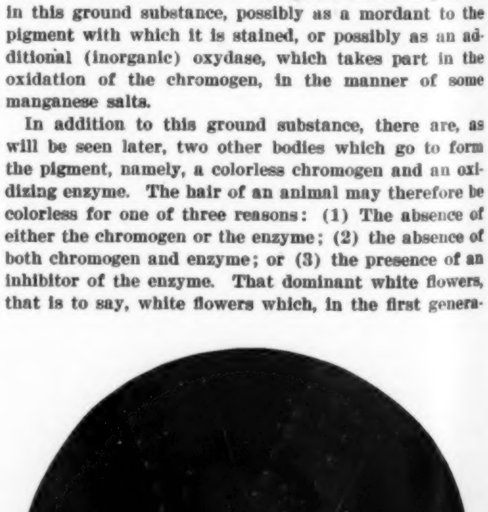


Fig. 5.—Chocolate mouse.[2]

tion, give white instead of colored offspring when mated to color, are due to an inhibitor, has already been shown. That a chromogen is present in the white hairs of the white Angora cat, the English, Dutch, and albino rabbit, as well as in the white belly of the wild rabbit, may be seen from the fact that there are present in these white hairs uncolored granular bodies, in the exact position occupied by the granule groups in colored hair.* Where the air has been expelled, in Fig. 2, they may be clearly seen, after staining in methyl violet, as groups of pigment granules.

Whiteness in these cases is therefore probably due to the presence of an inhibitor, and, in the case of the albino rabbit, to the absence of an oxydase. The white hair of the belly of *Mus sylvaticus*, as well as of albino and piebald mice, possesses, however, no granular body which is capable of taking an artificial stain, and whiteness in these cases is probably due to the absence of chromogen.

Black animals contain black and some chocolate pigment; chocolate and fawn animals contain chocolate and no black; yellow and cream animals contain yellow pigment, with the addition of some chocolate and black pigment, if the animal is heterozygous for black. The agouti, or common wild form of the rat, rabbit, or mouse, is a mixture of all three pigments; most of the hairs have a blue base, then a black and chocolate bar, next a yellow bar, and finally, as a rule, a chocolate tip. Occasionally, in certain mice called reversed sables, the yellow and black bars are interchanged. There is also in rabbits a modification of the agouti, called steel, which lacks the white belly and scut. The hairs have a much narrower bar of yellow, and more developed bars of black, which gives the animal a much darker appearance. A diagrammatic representation of a steel and of an agouti hair is shown in Fig. 3. White hairs, such as are found in albinos and piebalds, owe their brilliancy entirely to the large air-content and to the entire absence of pigment.

THE ACTION OF CHEMICALS.

The keratin of the hair is extremely resistant to the action of the reagents, and it is only dissolved by the action of caustic alkalies and strong mineral acids. Under the action of caustic soda the yellow pigment is first dissolved, forming a clear yellow solution; next the chocolate, forming a warm brown solution; and, finally, the black pigment granules settle to the bottom, undissolved. None of these solutions give absorption bands.

A very simple technique for examining hairs is to place them under a cover-slip, under which a drop of 10 per cent caustic soda has been run. The alkali immediately drives out the air from the vacuoles, loosens the epithelial cells, and permits the color of the granules to be observed, without the obscuring effect of the vacuoles.

* If white hair of the English or albino rabbit is treated as if for extraction of the black pigment, there results in both cases a small quantity of a grayish substance which turns black when dried on the water-bath, and is in appearance somewhat similar to the black pigment. The grayish substance also contains an appreciable amount of cholesterin.

The Legal Time in Various Countries*

How the Earth is Divided Into Twenty-Four-Hour Zones

By Dr. M. Philippot, Astronomer at the Royal Observatory of Belgium

TIME IN GENERAL.

Time is measured by the rotation of the earth about its axis. A day is defined as the time taken for one complete rotation. It is assumed that the axis is fixed in the earth and that the rotation is uniform. In order to measure the time taken for this rotation, it is necessary to have reference marks both in the sky and on the earth. For the latter the meridian is chosen, which is the plane passing through the earth's axis and vertical to the place where the time is measured. Two points are used in the sky: The first, the vernal equinox, which is the ascending node (intersection) of the ecliptic upon the equator; the second is the sun's center.[1]

The vernal equinox serves to determine the sidereal day, which is the time between two successive passages of the equinoctial point over the upper meridian of a place. The moment of this passage is taken as the beginning of the sidereal day. The hour angle of the vernal equinox gives the local sidereal time. For the affairs of civil life sidereal time is inconvenient and not used. It is used only for astronomical purposes.

The center of the solar disk is used to define the true solar day. On account of the variable movement of the sun along the ecliptic, the length of the true solar day varies from day to day and it is not feasible to make mechanisms or clocks keeping time with these irregularities. A fictitious sun has therefore been imagined, running its course along the ecliptic at a regular rate and reaching the points of its orbit nearest to and farthest from the earth at the same times as the true sun. A second imaginary sun is likewise supposed to pass along the celestial equator at a uniform rate and to be at the vernal equinox at the same moment with the first fictitious sun. This second imaginary sun is called the mean sun. The day measured by it is constant in length and is called the mean solar day. It commences at the moment when the center of the sun passes the upper meridian of the place. Mean solar time is used in all the affairs of civil life and our clocks are therefore regulated to it, not to true solar time.

In astronomical use, the beginning of the mean solar day is at the upper passage of the center of the mean sun across the meridian; that is, at mean noon; whereas the civil day commences at the moment of the lower passage (under the earth), midnight. In the first instance, we speak of mean astronomical time; in the second, of civil time. The latter is exactly 12 hours earlier than the former.

The difference between true and mean time is known as the equation of time.[2] The equation of true time is therefore the amount of time which it is necessary to add algebraically to true time in order to get mean time; the equation of mean time, what we must add to mean time to have true time. Accordingly, for the same moment, the equations of true time and mean time are equal in amount, but opposite in sign. The equation of time varies from day to day, but its greatest value is a little less than 17 minutes.

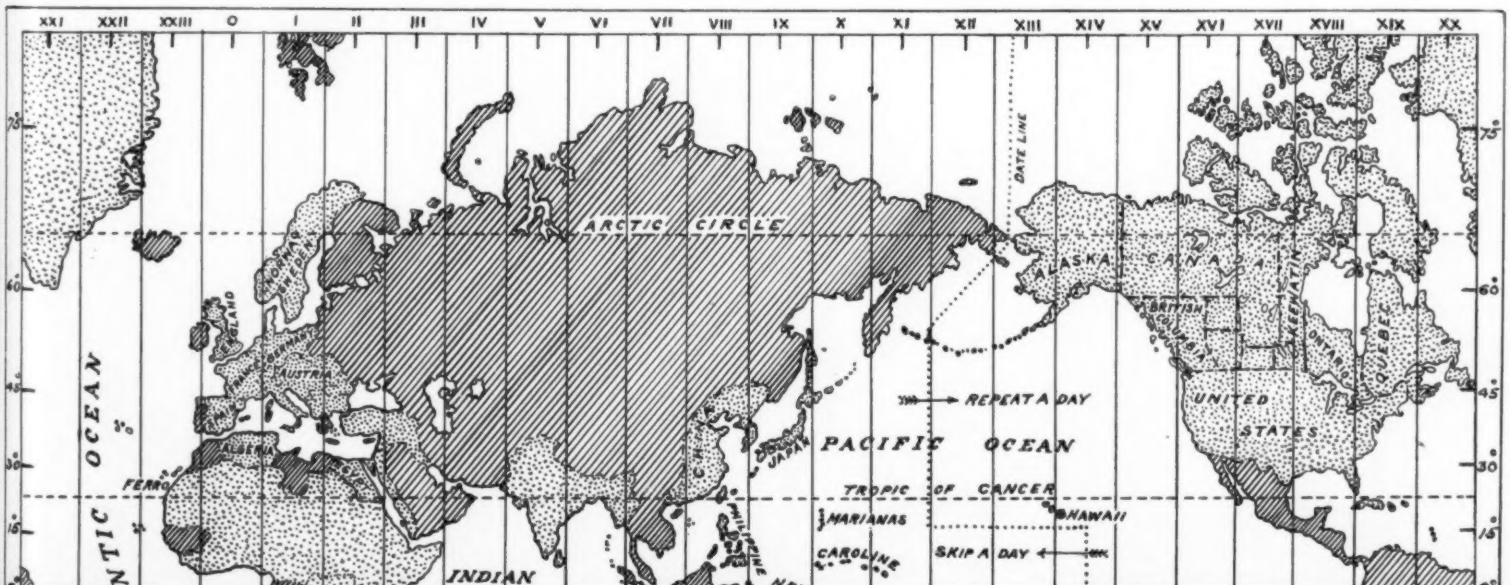
SOCIAL CONSIDERATIONS.

The principal affairs of daily life go on while the sun is above the horizon; that is, during the daytime.

* Translated for the Annual Report of the Smithsonian Institution by permission, with revisions by the author, from *Annuaire Astronomique*.

[1] The ecliptic is the intersection with the celestial sphere of the plane passing through the earth's orbit. The equator is the intersection with the celestial sphere of the plane passing through the earth's equator.

[2] The word equation is not used here in its mathematical sense; it is equivalent to the word "error."



Map showing countries that have and those that have not adopted standard time.

The sun, therefore, controls most of our actions, and it is but natural that it should serve to measure our time. Since the equation of time is always less than 17 minutes, the difference between the true and mean times is of little importance and brings no inconvenience into civil life.

All the general facts just stated apply to any place upon the globe. If each place were to adopt the time appropriate to its own meridian, called local time, the consequent diversity of time would result in great confusion. It is therefore advisable for the convenience of social life to adopt some conventional system of time for all the people of a certain region. Their clocks must be regulated to the time of some conveniently chosen meridian; there must be some standard time fixed either by law or custom. The choice of this depends on various considerations. The principal consideration seems to be that this time shall depart as little as possible from local time. In our choice of the meridian by which to regulate our clocks, we should therefore limit ourselves to one which passes through some central part of the region under consideration; then the difference between the local and the official time will be as small as possible in the extreme parts of that region.

The changing of the time at one locality to that corresponding to the same moment at another place, although a very elementary process, is one in which the uninitiated is very liable to make errors. As the transformation is generally wished quickly, it is important to reduce the process to its simplest state. Since the time defined by the mean sun is itself purely conventional, it may be used over a considerable region with little inconvenience. Thus, for the whole of a country may be adopted either the time corresponding to some point in its capital or to that of its principal observatory, whichever is preferable.

With the extension of international communication, quite naturally certain countries grouped together in the use of the time corresponding to some place near their center when this did not bring too great discordance with the true local time. But this effected only a partial solution and trouble still remained when it was desired to pass from the time of one group to that of another. An international agreement was necessary for considering this problem and bringing it to a rational solution.

SYSTEM OF ZONES—DIAL OF 24 HOURS.

In 1884, a conference, called together at the initiative of the United States, met at Washington for the purpose of coming to some understanding among the various nations of the world as to the choice of a standard meridian and a universal system of time. Several such systems were proposed. The conference, which, moreover, had no legal power, limited itself, among other resolutions, to recommending the adoption of the meridian of Greenwich and to the expression of their sentiment in favor of a universal system of time without committing themselves to any special system. However, during their sessions the delegates planned a system of hour lunes or spherical sectors, which was already coming into use in certain portions of North America. According to this scheme, the terrestrial globe is divided into 24 sectors, 15 degrees or 1 hour in width; that which extended 7.5 degrees or 30 minutes of time to the west and to the east of Greenwich was adopted as the initial sector. The time in any sector is exactly 1 hour ahead of the neighboring sector just to the west and 1 hour behind that just to the east.

The advantage of such a convention is that at any instant the time indicated by accurately regulated clocks the world over would be the same as to minutes and seconds, differing only in the whole hours; consequently in passing from the time of one place to that of another it is necessary to add or subtract only a whole number of hours. This process consists in combining two numbers of never more than two figures; thus the task is reduced to its minimum.

Evidently such a simple system must finally prevail from its own merits; consequently we find it coming more and more into use. The conference at Washington also recommended the adoption of a dial of 24 hours, which has the advantage that the use of the abbreviations A. M. and P. M. is unnecessary, as is the case with a dial of 12 hours. Unfortunately the spread of this reform seems to have nearly stopped. It is officially used at present only in Belgium, Canada, Spain, France, Italy and British India.

The civil day commences at mean midnight. For astronomical purposes a system of 24 hours is universally employed, but the zero hour corresponds to mean noon, so that mean astronomical time is exactly 12 hours later than mean civil time. This convention was adopted so that the same date could be used for all the observations of a single night. Although the conference at Washington resolved that as soon as practicable all astronomical and nautical dates over the whole world should commence at mean midnight, astronomers have not so done. English mariners indicate by P. M. the afternoon hours and by A. M. those of the forenoon.

The time corresponding to certain zones have received special designations:

Western European time, or western time, corresponding to the zone of Greenwich.

Central European time, or central time, corresponding to the zone 1 hour east of Greenwich.

Eastern European time, or eastern time, corresponding to the zone 2 hours east of Greenwich.

Eastern standard time, corresponding to 5 hours west of Greenwich.

Central standard time, corresponding to 6 hours west of Greenwich.

Mountain standard time, corresponding to 7 hours west of Greenwich.

Pacific standard time, corresponding to 8 hours west of Greenwich.

Since 1884 many countries have adopted systems of time based upon the zones and the meridian of Greenwich. In the following table are given the principal nations or portions of nations, the meridians adopted, and the difference between their standard times and that of Greenwich. The plus sign (+) indicates that the given difference must be added to Greenwich time in order to obtain the time in a given country; the negative sign (—), that it must be subtracted.

THE SYSTEMS OF TIME IN VARIOUS COUNTRIES.

Region or Country.	Meridian.	Difference.	Remarks.
Africa:		h. m. s.	
English south	Greenwich	+ 2 0 0	
German south	do.	+ 1 0 0	
Portuguese west	do.	+ 2 0 0	Legal time.
Portuguese east	do.	+ 1 0 0	do.
Argentine Republic	Cordoba	− 4 16 48.2	Official time.
Australia:			
Central	Greenwich	+ 9 30 0	
Western	do.	+ 8 0 0	
Austria-Hungary	do.	+ 1 0 0	Railroads.
Belgium	do.	0 0 0	Official time.
Canada:			
Nova Scotia	do.	− 4 0 0	Legal time.
New Brunswick	do.	− 5 0 0	do.
Ontario and Quebec	do.	− 5 0 0	do.
Keewatin and Manitoba	do.	− 6 0 0	do.
Alberta, Assiniboia, Athabasca	do.	− 7 0 0	do.
British Columbia	do.	− 8 0 0	do.
Chili	Santiago	− 4 42 46.1	Railroads.
China (eastern coast)	Greenwich	+ 8 0 0	Railroads, ports.
Colombia	Bogota	− 4 56 54.2	
Costa Rica	San Jose	− 5 36 16.9	Railroads.
Cuba	Havana	− 5 29 26.0	do.
Denmark	Greenwich	+ 1 0 0	Legal time.
Egypt	do.	+ 2 0 0	do.
Ecuador	Quito	− 5 14 6.7	Official time.
England and Scotland	Greenwich	0 0 0	Legal time.
Formosa, Pescadores	do.	+ 8 0 0	do.
France and Algeria	do.	0 0 0	do.
Germany	do.	+ 1 0 0	do.
Greece	Athens	+ 1 34 52.9	do.
Holland	Amsterdam	+ 0 19 39.0	do.
Honduras	Greenwich	− 6 0 0	
India and Ceylon	Madras	+ 5 20 59.1	
India, Portuguese	Greenwich	+ 5 0 0	do.
Ireland	Dublin	− 0 25 21.1	do.
Italy	Greenwich	+ 1 0 0	do.
Japan	do.	+ 9 0 0	do.
Korea	Greenwich	+ 9 0 0	Railroads.
Luxembourg	do.	+ 1 0 0	Legal time.
Mexico	Mexico	− 6 36 26.7	
Newfoundland	St. Johns	− 3 30 43.6	
New South Wales	Greenwich	+10 0 0	do.
New Zealand	do.	+11 30 0	do.
Nicaragua	Managua	− 5 45 10	
Norway	Greenwich	+ 1 0 0	Legal time.
Panama	do.	− 5 0 0	Railroads.
Peru	do.	− 5 0 0	Official time.
Portugal with Whydah and the islands St. Thomas and Principe	do.	0 0 0	Legal time.
Portugal:			
Azores and Cape Verde Islands	do.	− 2 0 0	do.
Madeira, Portuguese Guinea	do.	− 1 0 0	do.
Mauritius Island	do.	+ 4 0 0	do.
Macao, Portuguese Timor	do.	+ 8 0 0	do.
Queensland	do.	+10 0 0	do.
Roumania	do.	+ 2 0 0	Railroads.
Russia	Pulkova	+ 2 1 18.6	do.
Salvador	San Salvador	− 5 56 32.0	Legal time.
Servia	Greenwich	+ 1 0 0	Railroads.
Spain	do.	0 0 0	Official time.
Sweden	do.	+ 1 0 0	Legal time.
Switzerland	do.	+ 1 0 0	do.
Tasmania	do.	+10 0 0	do.
Turkey	do.	+ 2 0 0	Railroads.
United States:			
Eastern standard	do.	− 5 0 0	Legal time.
Central standard	do.	− 6 0 0	do.
Mountain standard	do.	− 7 0 0	do.
Pacific standard	do.	− 8 0 0	do.
Alaska	do	− 9 0 0	do.
Hawaii	do.	−10 30 0	do.
Porto Rico	do.	− 4 0 0	do.
Philippines	do.	+ 8 0 0	do.
Uruguay	Montevideo	− 3 44 51.4	Railroads.
Venezuela	Caracas	− 4 27 43.6	
Victoria	Greenwich	+10 0 0	Legal time.

This table makes easy not only the transformation of a given time to the corresponding time at Greenwich, but also its conversion to that of any other place. For instance, when it is 6 hours A. M. in Chicago, in Manila it is 6+6+8=20 hours, or 8 hours P. M.

Upon the terrestrial map given here, the 24-hour zones have been indicated; the central line of the first passes through Greenwich. The countries and territories which have not yet adopted the international system of time are shaded, the others are stippled. For great extents of country like the United States of America it is easy to see at a glance the time in each region.

THE INTERNATIONAL DATE LINE.

It is well known that if we go westward from America to Asia, we find our date one day behind time when we reach Asia; if we travel eastward over the same route we find our date one day ahead of time when we reach America.

In order to avoid this confusion of dates, it is customary, in crossing the 180th meridian from Greenwich, to "jump" a day, if traveling toward the west, and to repeat a day if traveling toward the east. However, because of geographical and political conditions, the international date line does not coincide exactly with the 180th meridian. It is an irregular line so situated that all eastern Siberia has the same date, the Aleutian Islands and Hawaii the same date as the United States of America, and, finally, the Fiji Islands and Chatham Island that of Australia. This line is shown on the accompanying map.

THE TIME SERVICE OF VARIOUS COUNTRIES.

The knowledge of the exact time is of the utmost importance for the transaction of the business affairs of all the nations; especially so for those who have charge of the means of transportation and of rapid communication. This is the case for railroad and telegraph companies, and especially for maritime commerce. The captains of vessels, at the moment of clearing for sea, must be able to regulate their chronometers with precision, for upon these instruments depends the determinations, during their voyage, of the geographical positions of their vessels. Accordingly, at the principal ports of the world, a special device (time ball) is used to give the mariners the exact time at known moments. Indeed, in certain ports, special bureaus for this purpose are at the service of sea captains during their stay in port; here they may deposit their chronometers so that their conditions and daily rates may be determined. These time-service bureaus are generally in direct communication with an astronomical observatory, which assures them of the time used.

Various countries of the world have organized, according to their means and local necessities, more or less extensive time services.

Generally, in countries covered by a network of telegraph and telephone lines, a service is established such that the various bureaus connected by wire receive daily the necessary time signal. Those wishing signals can apply to these offices or rely on time furnished to exterior clock dials either at railroad stations or at post offices.

In the United States of America the time is sent over all its immense extent of land. It is transmitted at noon by an accurately regulated pendulum which automatically sends currents of electricity over all the telegraph lines of the country. These currents actuate receiving instruments at all the telegraph stations. The duration of the transmission lasts five minutes. They are sent out from the Naval Observatory at Washington for all the region east of the Rocky Mountains, and from the observatory at Mare Island, Cal., for that to the west. Besides these noon signals, others can be sent during the course of the day when required.

In Portugal the Lisbon-Tapada Observatory furnishes telegraphically the time to the whole country, to the time ball at the arsenal at Lisbon, and to the chronometer station of the meteorological observatory of Ponta Delgada (S. Miguel, Azores)

In Belgium the time is sent daily by telephone to the time-service office at the port of Antwerp, where an assistant is detailed to compare such chronometers as may be deposited. An accurate Riefler clock serves to maintain the requisite time and work the time ball. The observatory sends the time also to the central bureau of the telegraphs which in turn distributes it to all the telegraph and railroad stations of the kingdom.

The precise time is sent also to the various civic departments as well as to certain private institutions to which it is essential. The transmission of the time is made as follows: As soon as the one in charge of the station is in telephonic communication with someone wishing the time, he states the time he is going to indicate, to the exact minute generally, then, 10 seconds before that time he calls, "attention," and then accurately at the minute he says, "tip." His "tip" is rarely out by two tenths of a second.

[*In practice it is not found convenient to employ time zones bounded strictly by meridians. Hence, a compromise is struck. We have had occasion to illustrate this in an earlier issue. A map of the United States, showing the practical lines of division employed will be found in our issue of November 20th, 1913, page 3[illegible]1.*—EDITOR.]

Macadam as a Base for Brick Roads.—In Allegheny County, Pa., the existing macadam roads are used as a base upon which to construct modern and more durable roads of brick or concrete. The macadam is scarified and trued up, concrete curbs are built, the bed of sand is put in place and the bricks laid thereon. The surface is then grouted with a mixture of equal parts of sand and cement. In another type of road bituminous concrete is laid directly upon the macadam surface after the latter has been scarified and trued up, and the finished surface is then carefully rolled.

Insulation for Cold Storage*

Tests of Several Insulating Materials

By Prof. Henry Payne

The author recently had occasion to inquire into the value of some insulating media, in consequence of the erection of certain cool stores, and therefore takes this opportunity of placing the results of his investigations on record.

It may be well to summarize the requirements for a good insulating material as given by a number of writers on the subject.

Material for insulation of cool stores should be: 1. A good non-conductor of heat. 2. Fire-proof. 3. Durable: (a) vermin-proof; (b) fungus-proof; (c) not liable to bacterial action. 4. Non-hygroscopic or deliquescent. 5. Not liable to silt. 6. Not entailing a costly mode of application. 7. Inexpensive. No one material stands pre-eminent in relation to all these requirements, and it must remain for the engineer or architect to select for himself that which most nearly suits the problem he has to deal with.

Experiments were made for the purpose of ascertaining from a number of materials the relative values of the above-mentioned requirements 1 and 5. The materials selected were: (1) silicate cotton (mineral wool); (2) wood charcoal; (3) pumice; (4) buzza chips; (5) cork. The silicate cotton was locally manufactured at Yarraville, and was packed to a density of 13 pounds per cubic foot when used for insulation purposes. Wood charcoal was bought in Melbourne, and readily passed through a half-inch mesh sieve. It was free from dust and dry. Pumice was also purchased in Melbourne, and contained a considerable quantity of small material, together with some dust. Buzza chips, as the name indicates, come from timber yards. Cork was provided in sheets, being compressed into slabs of 2-inch thickness, and the slabs were jointed together with a cork cementing material.

To compare the various materials three sets of experiments were carried through—one set comparing the materials when filling in the space between timber partitions, the second set comparing the materials when placed between thin galvanized iron partitions, both these to determine their relative conductivity, and the third set to determine their liability to silt under a continued shake over extended periods.

The apparatus used for determining the first set of experiments is shown in Fig. 1, which consists of a case *A*, formed with hollow walls *B*, into which the insulating material was placed. The partitions forming these walls were each constructed with two thicknesses of ¾-inch flooring boards with the usual brown refrigeration paper between them, the total thicknesses of these walls being 9 inches. The mode of filling in the material was by turning the case top downward, and carefully filling it with the bottom *C* removed, uniformity in packing being looked to by pressing each layer of material into the space allotted to it. The cover *D* was similarly packed from its end *E*. The case was then placed upon wood blocks *K*, so as to allow for the free circulation of air around the case during the test. In order to determine the amount of heat that would be conveyed through these walls, ice *I* was placed in the case on a thin galvanized iron tray *F*, which drained any water coming therefrom through a ¼-inch India rubber tube *G*, when the clip *H* was opened. This water was collected in the beaker *J* at intervals and weighed. Through the cover *D* a ¼-inch India rubber tube *L* allowed the introduction of a low reading thermometer *M*, for the purpose of ascertaining the internal temperature of the case; thus the difference of temperature existing on the two sides of the wall of these cases was determined.

The case in Fig. 1 had the following principal dimensions: Internal volume, 27 cubic feet, the volume of insulating material filled in between the partitions was 40.45 cubic feet, while the total volume of the case was 91.75 cubic feet. The inner area of the case was 54 square feet, its outer area 121.5 square feet, and the mean area (including wooden partitions) was 85.5 square feet, which mean area has been selected for arriving at the relative values of the walls packed with the various insulating materials.

In order to obtain uniform temperature ruling in the room in which the cases were placed, the doors were kept closed, except when the observers passed into an adjoining room for the purpose of weighing the water which was periodically drawn off. This weighing room had no other means of entrance but from the test room, and so was not a greatly disturbing factor. Further, two electric fans were at work during the whole of the test periods keeping the air in constant circulation, and were similarly placed in relation to the various cases used.

Tests were carried out over extended periods with continuous observations taken every quarter of an hour, and were continued until such time as the internal temperature became constant for a constant external temperature. Such constant external temperature was in each case in the region of 65 deg. Fahr., 80 deg. Fahr. and 100 deg. Fahr. The periods over which observations

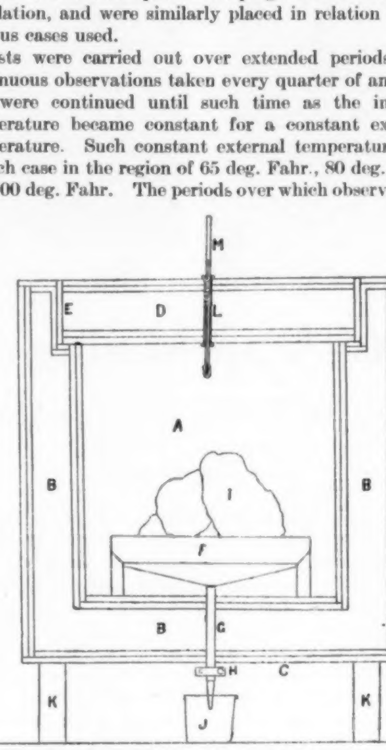


Fig. 1.—Apparatus used to test insulating qualities of different materials.

were taken at these temperatures were such that three and four hour periods of uniform working could be taken for comparison. The total continuous runs varied from 24 hours to 48 hours.

The conductivity results obtained from a large number of calculations are:

Wall packed with silicate cotton	0.230
Wall packed with wood charcoal	0.265
Wall packed with pumice	0.332
Wall packed with buzza chips	0.305

These figures are at 90 deg. Fahr., and represent the number of British thermal units transmitted per hour, per degree difference of temperature on the two sides, per square foot of area (mean area of insulation being taken) per inch thickness of insulating material; or if the results are compared on the basis of wall packed with silicate cotton at 100 they are:

Wall packed with silicate cotton	100
Wall packed with wood charcoal	114
Wall packed with pumice	144
Wall packed with buzza chips	132

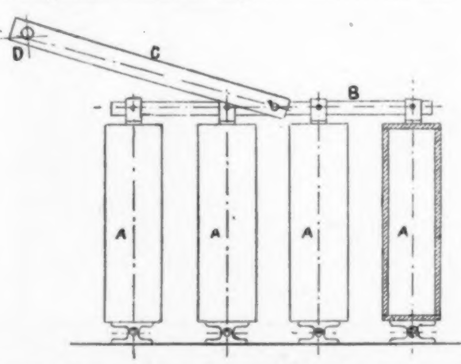


Fig. 2.—Apparatus employed to determine degree of settlement of insulating material.

The weights of material used for packing the walls were:

Silicate cotton	13.03 pounds to the cubic foot
Wood charcoal	13.62 pounds to the cubic foot
Pumice	23.60 pounds to the cubic foot
Buzza chips	6.87 pounds to the cubic foot

Since, in the above results, it was clear that the wooden partitions were in a measure shrouding the relative values of the four materials, the second series of tests were carried out, but the cases were of light galvanized sheet iron. The inner cube was 1 foot by 1 foot by 1 foot, and the outer cubes were constructed so as to provide thicknesses for the insulating material of 2 inches and 6 inches for silicate cotton; 6 inches for wood charcoal; and 2 inches, 4 inches and 6 inches for cork, the inner temperatures being observed in the same manner as in Fig. 1. A similar method of withdrawing the water due to meltage was adopted.

With this second set of experiments a large number of results were obtained for conductivity which do not differ from the following figures:

Silicate cotton	0.203
Wood charcoal	0.298
Cork	0.219

Or when based on silicate cotton at 100 they are:

Silicate cotton	100
Wood charcoal	146
Cork	108

These figures were determined from the difference of temperature between the room and the inside of the cases, and do not vary with the temperature or with the thickness of material for the 2-inch, 4-inch and 6-inch walls.

Taking the results obtained from this second set of experiments and applying them to the first set, it would appear that the value for the conductivity of the wooden partitions (see Fig. 1) as constructed is 0.255 British thermal unit per hour, per degree, per square foot of mean area, per inch thickness. So that the shrouding effect, when comparing walls packed with silicate cotton and walls packed with wood charcoal, is that silicate cotton appears in a worse aspect than wood charcoal when packed in between timber partitions (0.230—0.265 or 100—114) than when acting by themselves (0.203—0.298 or 100—146).

The third series of tests, namely, those to determine the amount of silting or settlement, were carried out in the apparatus shown in Fig. 2. Shake-boxes *A* were constructed so that each contained a cubic foot of material 6 inches by 12 inches by 24 inches, the top of the box receiving a to-and-fro motion of one half inch at a distance of 25 inches above the rocking point. The four shake-boxes were coupled to a rod *B* by pins, this rod receiving its to-and-fro motion through the connecting rod *C* worked from an eccentric *D*. The rate of the to-and-fro motion, that is, the number of revolutions of the eccentric, was about 320 per minute.

The weights of material packed into these shake-boxes were respectively:

Silicate cotton	13.0 lbs.
Wood charcoal	14.9 lbs.
Pumice	23.2 lbs.
Buzza chips	6.8 lbs.

The author is not aware of a shake test on similar lines being carried out heretofore, hence the following table:

Time.	Revolutions of Eccentric.	Settlement in 1/16th inch.			
		Silicate Cotton.	Wood Charcoal.	Pumice.	Buzza Chips.
0 min.	0	0	0	0	0
1 min.	333	0	1	1	2
5 min.	1,620	0	5	3	7
12 min.	3,727	0	9	5	9
30 min.	9,705	0	15	6	13
60 min.	19,432	0	17	7	16
2 hrs.	39,522	0	22	8	18
5 hrs.	....	0	26	11	21
12 hrs.	....	0	33	14	24
24 hrs.	....	0	36	16	25
48 hrs.	....	0	38	24	27

Unfortunately the counter became disarranged when running between the two and five hour periods, and was no longer used.

The wood charcoal on the top surface became very rounded, due to the constant abrasion. The top two inches of pumice also consisted of somewhat more rounded material than before the test. On unscrewing the sides of the boxes after the test it was evident that the materials had settled themselves into a closely packed uniform mass. The wood charcoal showed considerable powdered material in the bottom six inches; the pumice also exhibited some increase in its dust, but this dust was uniformly distributed throughout the mass except in the top two inches; the buzza chips showed by pressure of the hand less indentation at the bottom than at the top, and appeared to gradually taper in density from bottom to top, and the silicate cotton remained uniform; it did not appear to have changed in the least during the test.

* Abstract of a paper read before the Vic. Institute of Engineers and published in the *Commonwealth Engineer*.

In the armor plate works.

View of one of the rooms in the iron foundry.

An Important Austrian Mining and Iron Works

The Moravian Center of the Iron Industry

By J. A. Seager

THE name of the Witkowitzer Bergbau-und Eisenhutten-Gewerkschaft of Witkowitz, Moravia, is intimately associated with the leading developments in the iron and steel industry of Central Europe.

It would be impossible to deal in detail with all the departments of these iron works, but some brief particulars may be given. The Sofienhütte and Witkowitz Blast-furnace Works deal with Upper Hungarian spathic and brown iron ores, Styrian, spathic iron ores, Swedish magnetic iron ores and apatites, elixivated calcined pyrites, slags, manganese ores from Bosnia, the Bukowina, Hungary and Russia, together with manganese ores imported from over the seas. There are seven blast furnaces with thirty sets of blast-heating apparatus and eight blowing-engines driven by steam, eight others being driven by gas engines. The products of the iron works include puddling, steel foundry, white, hematite, Bessemer, phosphorus, and chill-casting pig-iron, together with ferro-silicon and silico-spiegel iron. At the puddling works at Mahrisch-Ostrau, there are eight single and eight double furnaces, three rotary and four rotary gas-puddling furnaces, together with six steam hammers, nineteen steam engines, with two shingling roll trains. The puddling-pig produced by the Sofienhütte works is worked up into rough rails and billets.

The older plants at the steel works and rolling mills include five Martin furnaces, each having a charge capacity of twenty tons. Steel is produced at these works on the combined system, for which two converters, holding a charge of ten and one half tons each, are used. There are also two Martin furnaces, for twenty-two and thirty tons' solid charge, respectively, The rolling mills comprise two separate mills, one being equipped for producing ships' boiler and tank plates, rails, girders, constructional irons, strip iron for tube manufacture, wire billets, rail sleepers, and armor plates. This division contains eight roller trains. The largest driving engine has an efficient power of up to 4,000 horse-power. The second rolling mill produces, on five roller trains, merchant iron, strip iron for tube manufacture, rails for mines, and small profiled irons, partly of puddled iron, partly of mild steel. The material is welded in ten rotary recuperative gas-welding furnaces. Adjoining the rolling mills is the finishing workshop with cold saws, plate shears, dressing machines, edge-stripping machines, circular saws, and other auxiliary plant.

In 1909 the erection was commenced of new steel works and rolling mills, the completion of which will be effected in the present year. They are built on a site situated in the communal district of Zabreh, at a distance of about one and one quarter miles from the older works, and are of a most modern description in every respect. The steel works are arranged for working liquid pig-iron from the Witkowitz blast furnaces, and the first equipment consisted of a Talbot mixer of about 300 tons' capacity, a 200-ton Talbot furnace, a 50-ton tilting Wellmann furnace, and three stationary furnaces of 50 tons' capacity each. This plant was erected to ascertain the most favorable process of working under the conditions existing at Witkowitz, and the further extensions have been carried out in accordance with experience gained in working the various furnace systems. The new rolling mills comprise an ingot-rolling mill, a reversing-roller train, a rough-rolling train, a plate duo, two plate trio, and two universal roller trains, together with several intermediate and finishing roller trains to which an armor plate-rolling mill is added. All the roller trains, as well as all subsidiary plant, are driven exclusively by electricity generated by the extensive utilization of the available coking-kiln and blast-furnace gases, in several power stations which will be mentioned later. An armor plate-rolling train, which was installed in August, 1910, with rolls of 14.76 feet, length of working face, and 4.10 feet diameter, and a duo plate-roller train was installed in 1912, having rolls of 10.5 feet length of working face. There is a roller-turning shop with twenty-six roller-turning lathes, and a repairing workshop with twelve machine tools attached to this section.

In the steel foundry there is a plant of eight Martin furnaces of 13 to 35 tons' capacity. Two crucible furnaces, hammer and press plant, tire-rolling mill, projectile-pressing plant, and armor plate works with finishing shops. There is also attached to this section a steel molding shop and steel foundry and finishing shops for steel castings and forgings, a plate press building, and a gun range, with guns of various bores. In this section are produced steel castings and forgings for machinery and shipbuilding, Martin, crucible, and special steel of all kinds, axles, tires, locomotive wheels, carriage disk wheels both cast and forged, rough castings and forgings for gun barrels, gun carriages, projectiles, torpedo-air reservoirs, armor plates for men-of-war and fortifications, boiler-end plate, and pressed plates of all kinds. In addition to the steel foundry, there is an iron foundry, in which there are eleven cupola furnaces, four reverberatory furnaces, twelve molding machines, and thirty-seven cranes of 2,200 to 110,000 pounds' lifting capacity. Cast-iron pipes, for gas and water, up to 1,500 millimeters inside diameter, chill molds, roller constructional and machinery castings of up to 220,000 pounds each are produced.

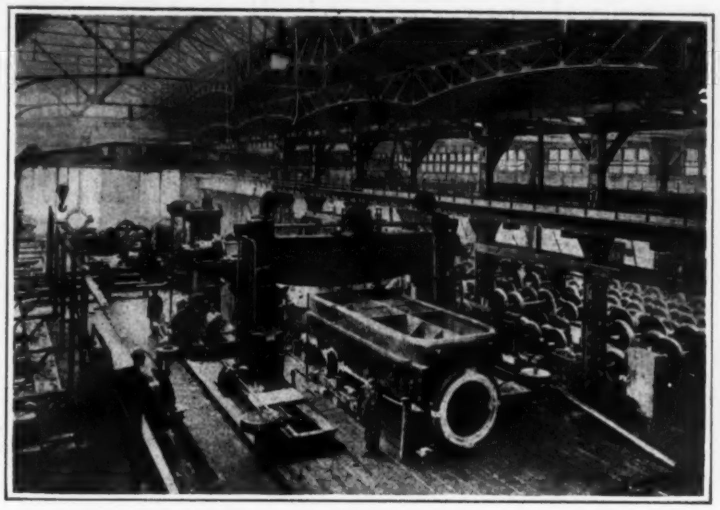
Eight thousand ton armor-plate-bending rolls.

A section of the undertaking is devoted to engineering works for the production of machinery and plant required for mining, as well as for the company's own works, such as steam and electric winding and haulage plants, pit-head gears, separating plants, coal-washing plants, compressed-air locomotives for mines, installations for coking kilns, complete mechanical equipments and fittings for blast furnaces, blast-furnace blowing engines, construction of cranes, gas-works plant, complete rolling mill and metallurgical plants, large gas engines, compressors, and the manufacture of forgings and pressed goods, projectiles, turning-tables, railway carriage wheels, junction and switch-point installations. The principal products of the bridge-building works are railway and road bridges, caissons, metallurgical plants, crane installations, electric light and conductor standards, etc. For fitting up and assembling the part of such constructional work, there are, beside the machine tools in general use, pneumatic and hydraulic machines, pneumatic tools, and six cranes with electrically driven drilling machines. In the boiler works, which are equipped with the most up-to-date plant, such as electrically driven loading cranes, pneumatic tools for drilling, riveting, and mortising, etc., a large range of products are made, such as distilling boilers of all kinds, super-heaters, vats for water, spirit, crude oil, petroleum, etc., up to the largest dimensions, distilling apparatus, brewing vats, coolers, cellulose boilers, riveted piping, gas-holders, etc. A tube-rolling works is also installed, for producing butt and patent-welded as well as seamless tubes of mild steel and puddled-iron for water, gas and steam, receivers, pipe worms, fittings, and corrugated tubes.

Among other sections, may be briefly mentioned welding plants operated both by water-gas and electricity, the former producing pipes up to the largest diameters for high-pressure and turbine conduits, together with a large range of iron plate goods, fashioned goods, boilers for stationary and locomotive engines, water chambers, etc. Electric welders are used for welding thin plate, such as is used for barrels or drums for the transport of petroleum and benzine. There is a coal-dressing and coking plant, with 209 coking kilns equipped for the exploitation of by-products, such as ammonia, benzol, and tar, a copper-extraction plant for extracting the metal from about 140,000 tons of calcined, cupriferous pyrites annually, a lime ring-kiln and a ring-kiln brick-works, producing about six million machine bricks per year for the firm's own use, and a refractory brick-works for producing all kinds of refractory material, especially complete linings for blast furnaces, blast-heaters, coking kilns, Martin furnaces, puddling and reheating furnaces.

In connection with the firm's operations, there are four central electric power-generating stations. The

One of the huge conveyers.



Some heavy machine tools.

first is worked by steam, and contains four continuous-current dynamos, generating, altogether, 2,452 kilowatts at 525 volts, two three-phase alternators, capable of generating 2,000 kilowatts at 5,250 volts and 50 periods, and a 1,000-kilowatt transformer for converting three-phase to continuous current. The second power station, which is operated by coke oven and blast-furnace gas engines, contains four continuous-current dynamos, giving a total of 2,820 kilowatts at 525 volts, together with provision for extension. The third power house is situated at Sofienhütte, and is also worked by blast-furnace gas engines. It contains two 1,000-kilowatt three-phase alternators, giving current at 5,250 volts, and has, also, provision for future expansion. The fourth power station, at Witkowitz, contains six 2,000-kilowatt three-phase alternators running at 5,250 volts and driven by blast-furnace gas engines. In addition to these main stations, there are forty-two smaller dynamos placed in various departments throughout the works, for various special purposes. There is a gas-works department in connection with the firm, which not only supplies gas for use in the works, but also for the communal districts of Witkowitz and Zabreh. A building department attends to the execution of all works of construction, whether for the firm itself, or under building contracts, partly by its own staff of workmen and partly by workmen supplied by outside contractors. Other departments of the firm include a central drawing office, a chemical laboratory, and three test offices. In connection with these, there are five tensile test machines capable of dealing with 22,000 to 176,000 pounds maximum test loads, two bending-test machines, two shock-test machines, a load-test machine exerting a pressure of up to 90,000 kilogrammes, a compression-test machine, and a ball-pressure-test machine with a pressure of 110,000 pounds. The traffic between the various departments and the Schonbrunn-Witkowitz and Mahrisch-Ostrau stations of the Northern Railway is carried on by means of full-gage haulage railway tracks of an aggregate length of 108 kilometers, and narrow-gage railways of an aggregate track length of 73 kilometers. There are 23 narrow-gage railway engines, 1 steam rail motor truck, 952 goods trucks, and 21 passenger coaches included in the full-gage rolling stock belonging to the works. The goods traffic carried on the works' full-gage railway in 1911 amounted to 5,482,300 metric tons. On the narrow-gage railway the traffic is served by 32 locomotives and 1,763 carriages. For weighing purposes, there are 13 weigh-bridges, having a bearing capacity of 66,000 to 154,000 pounds.

The iron works own, for the accommodation of the officials, foremen, and workmen, 272 dwelling houses, with 427 tenements for officials and foremen, 1,517 family tenements for married workmen, 6,418 beds in thirty-two barracks for single men and married men living away from their families, and 115 beds in fifty-eight rooms for such workmen as prefer to live in separate rooms, or two in one room. A home for the aged, comprising five houses with sixty dwellings, gives free accommodation to old and deserving workmen. The works also maintains a works' hotel, a co-operative store with two branches, 14 canteens, and 4 soup kitchens and refreshment rooms. Education is looked after in a middle-class German boys' and a middle-class German girls' school, four German boys' and three German girls' elementary schools, a Bohemian boys' elementary school, a Bohemian girls' elementary school, a Polish elementary school, sixteen kindergartens, and an infants' crèche, a German continuation trade-school for training future members of the supervising staff, a general continuation trade-school for all apprentices, and a holiday home established by the iron works in a mountainous region gives accommodation and recuperation to 108 children of workmen employed at the works during their Summer holidays. In commemoration of the jubilee of the reign of His Majesty the Emperor of Austria, an orphanage was built for 50 boys and 50 girls, which has since been enlarged by two annexes, and the orphans, on leaving the orphanage, receive outfit allowances. The number of persons employed in 1912 at the iron works and iron mines was 19,099 workmen and 1,097 officials and supervising staff, while at the collieries 10,230 workmen and 562 officials were employed. In 1912 the Rudabaya Iron Mines produced 410,000 tons of ore. The Kotterbach Iron Mines produced 176,568.6 metric tons of spathic iron ore, together with 85.5 metric tons of mercury, while the output of the iron mine of Koskuliskulle in 1911 was 243,059 metric tons of magnetic iron ore. In addition to this, at the Witkowitz collieries, with their ten shafts and two coking plant installations, the coal extracted in 1912 was 2,409,700 metric tons, the coke produced was 559,550 metric tons; 6,501 metric tons of sulphate were obtained, while the tar and pitch produced amounted to 20,534 metric tons. Equally remarkable figures were obtained in the iron works departments; some idea of the work done being obtained from the fact that in the testing shops, 44,251 tensile tests and 5,800 bending tests were carried out, while in the chemical laboratories altogether 147,032 tests were undertaken in the same year. We are indebted to the courtesy of the management of the Witkowitzer-Bergbau-und Eisenhütten-Gewerkschaft for placing these particulars and the illustrations which accompany this article at our disposal, as it exemplifies the great development which has taken place in the central part of Europe in the direction of modern iron and steel-manufacturing processes and the coal-mining industry.

The Development of the Aeroplane—I*

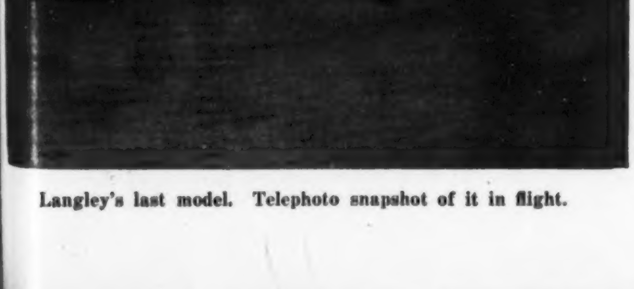
What Experiment and Scientific Research Have Done for the Advancement of Aviation

By Dr. R. T. Glazebrook, F.R.S., F.Ae.S.

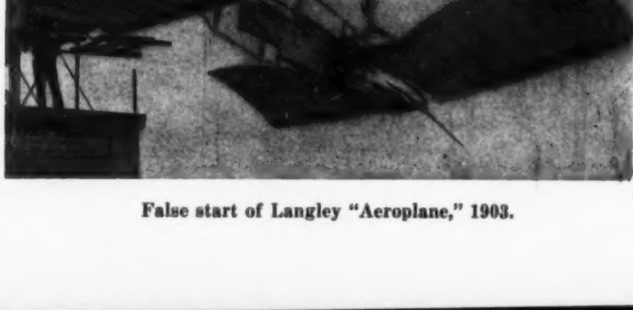
EARLY EFFORTS.

In reviewing the early history of aviation, we commence with Henson's aeroplane, designed in 1842 and never constructed, and Ader's, who in 1897—the year after Langley's experiment—succeeded in flying or possibly rather hopping short distances in a machine weighing 1,100 pounds, driven by a steam engine of 40 horse-power, weighing 7 pounds per horse-power. Fifty years before this, Stringfellow, in 1848, had constructed a small model which flew some 40 yards under its own steam, while in 1868 he exhibited a triplane at the Crystal Palace. Langley's first aeroplane dates from 1896. Then

* The second Wilbur Wright Memorial Lecture, delivered at the Royal United Service Institution, Whitehall, on Wednesday, May 20th, 1914.



Langley's last model. Telephoto snapshot of it in flight.



False start of Langley "Aeroplane," 1903.

we have Langley's quarter-size model of 1901; in this, he had Manley's help. Langley's large aeroplane was built in 1903—the same year in which the Wrights made their first flight at Kitty Hawk with a machine weighing 750 pounds and a 16 horse-power motor; then follow

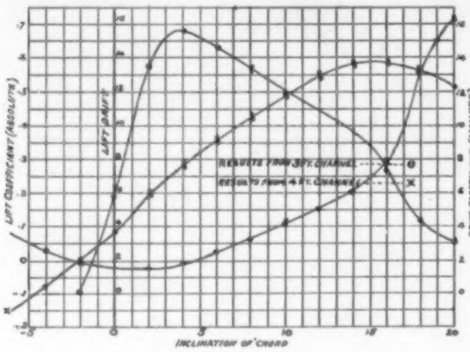


Fig. 1.

Ferber in 1903; Phillips, 1904; Wright's machine of 1905; and Santos Dumont of the following year, 1906.

DEVELOPMENT SINCE THE WRIGHTS' FIRST FLIGHT.

Let us pass on to more modern days. It is only some ten years since Wilbur Wright and his brother flew in their first machines at Kitty Hawk—seven or eight years since they astonished the world by the success of their flights in France, and yet how great has been the change! Compare the machines with those exhibited recently at Olympia. Development due to the labors of many workers, the thoughts of many minds, the skill and experience of pilots in many lands, was shown on every side. The task of tracing in all its details the growth of that development is too heavy for a single evening and, indeed, if I could attempt it I could not make it interesting. I wish to limit myself to one corner of the field—I propose to deal mainly with the work of experiment and scientific research in the development of the aeroplane. Laboratories for the study of aeronautical problems exist in many places and each has contributed to our present knowledge. No small share belongs to the National Physical Laboratory, where Dr. Stanton, Mr. Bairstow and their colleagues have worked with so large a measure of success, and if to-night I am able to put before you any new facts connected with our subject it is solely due to the zeal and skill with which the Laboratory Staff have attacked and solved the complex and most interesting problems proposed to them.

The experiments I propose to consider are all conducted, as you know, in an air channel. A model of the aeroplane, or the part of the aeroplane whose behavior it is desired to study, is supported in the channel on the arm of a balance, by means of which forces and moments acting on it when a current of air is produced in the channel by a suitable fan can be measured. I will not attempt to describe the mechanism—many of my hearers have seen it. The velocity of the air current is measured by a Pitot tube and the precautions taken have secured a constant distribution of velocity across nearly the whole of any section of the channel.

We wish, however, for information as to actual aircraft, not merely models, and our success in obtaining this will depend on the accuracy of our measurements and our knowledge of the law which connects the forces on the model with those which act on the aeroplane itself.

As to the accuracy of the results—there are now two channels, one 3 feet square, the other 4 feet square, in daily work; a third large channel, 7 feet square, is nearly complete. Recently the lift and drift of the same aerofoil were measured by different observers in the two channels. The results are shown in Fig. 1, those in the 4-foot channel being indicated by an X, those in the 3-foot by an O, the two series are practically identical; the accuracy attained is very high.

Samuel Pierpont Langley.

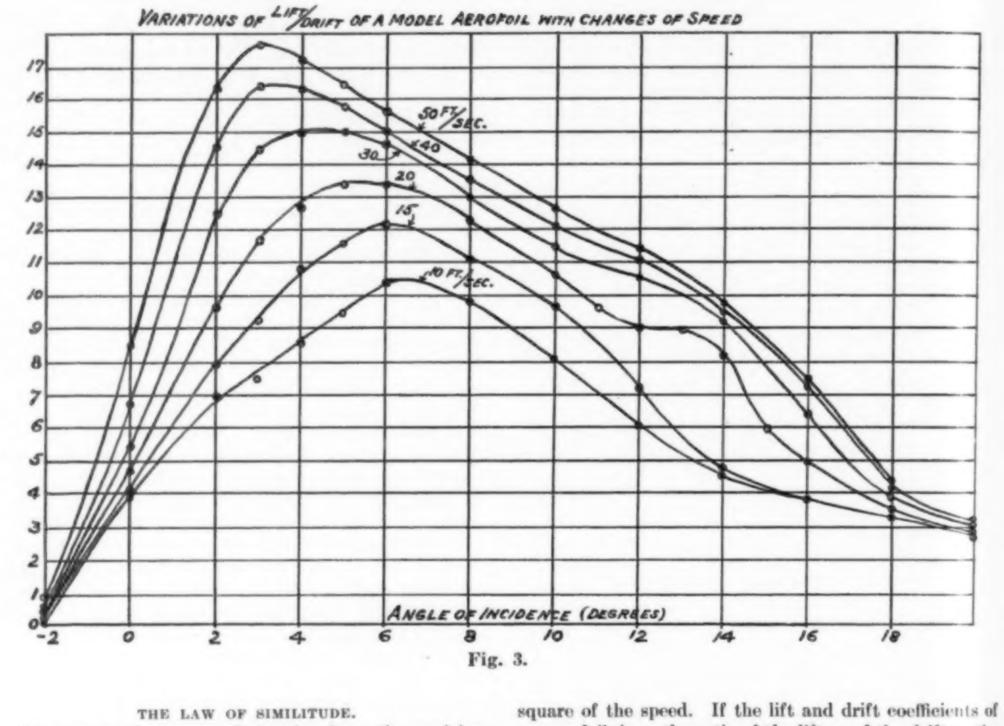


Fig. 3.

THE LAW OF SIMILITUDE.

Next as to the means of stepping from the model to the aeroplane; it is known that the force on a surface

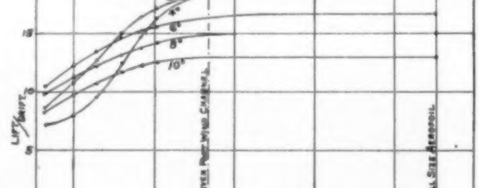


Fig. 4.

due to the wind may be written as KSV^2, S being the area of the surface, V the speed of the wind, and K a quantity which for two similar surfaces similarly placed is approximately a constant, independent, that is, of the velocity and the area. If K were really constant, the step from model to aeroplane would be simple; to obtain the force on the aeroplane at a given speed it would merely be necessary to measure that on the model at some speed and increase it in the ratio of the area of surface of the aeroplane to that of the model and of the squares of the respective velocities. But experiment proves that the force is not strictly proportional to the

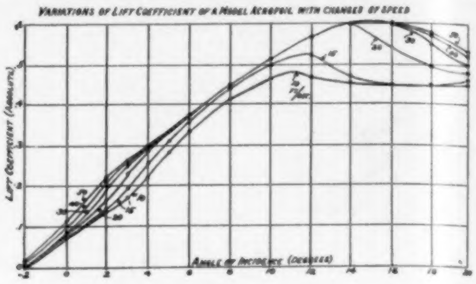


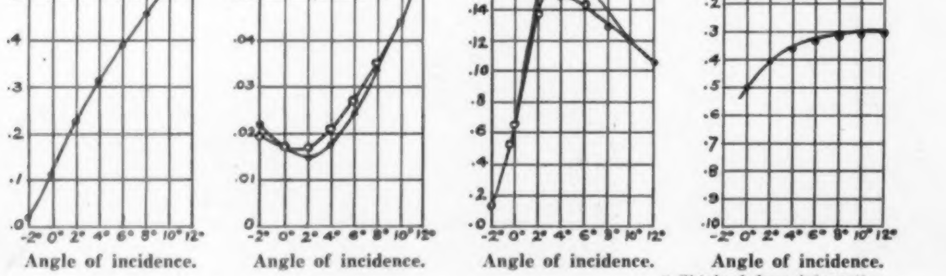
Fig. 2.

square of the speed. If the lift and drift coefficients of an aerofoil, i. e., the ratio of the lift or of the drift to the square of the speed, be determined, they are found to vary with the speed. This is shown in Figs. 2 and 3, which represent the result of such a series of experiments, and in which, as the speed changes from 10 to 50 feet per second, there is a growth in the coefficients.

At an early point in the work of the Advisory Committee for Aeronautics, Lord Rayleigh called attention to the fact that if K be not constant for similar surfaces it must depend on the quantity $\frac{VL}{\nu}$, or, in mathematical terms, be expressible as a function of $\frac{VL}{\nu}$ where V is the velocity of the current, L some linear dimension of the surface, and ν the kinematic viscosity of the air. If then we plot the value of K as found for an aerofoil in a given position, but for different values of the velocity against VL, the spots ought to be on a smooth curve and the form of this curve will determine K as a function of VL. This has beeen done in Fig. 4, where the values of the lift to the drift ratio are plotted against VL (or rather, for convenience against log VL) for the series of experiments shown in the preceding curves.

Again, experiments have been made at the Aerodynamical Laboratory of the University of Paris on full-sized aerofoils. These have been repeated at the Laboratory on models one sixteenth of the scale, and when the results are reduced by the above law, the agreement in the lift experiments is practically complete; the measurement of the drift is more difficult and the agreement is less good, but the results for the ratio are given in Fig. 4, and it appears that at the highest value of VL yet reached in the model experiments the value of the ratio lift-drift is somewhat less than for the full-scale experiments, but that values for the coefficients found from the 50-foot per second observations in the channel do not differ greatly from those belonging to the actual machine. This point can be checked more fully when the large channel is complete, and the necessity of checking it afforded a strong reason for the building of that channel.

There is another method, however, of checking the accuracy of the model work which has been pursued with



Angle of incidence. Angle of incidence. Angle of incidence. Angle of incidence.

● Obtained from integration.
⊙ Obtained from force experiment.

Fig. 5.

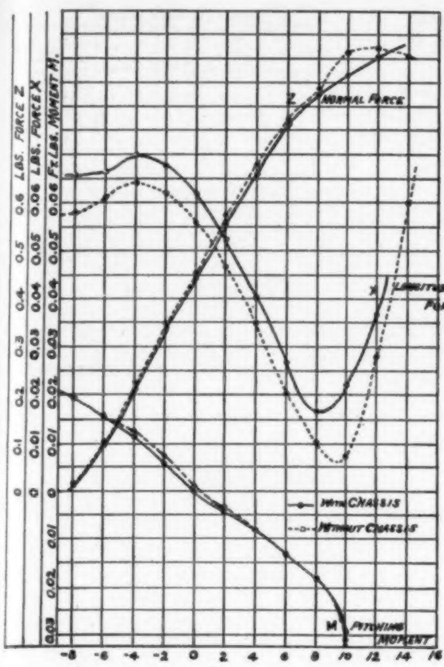


Fig. 7.

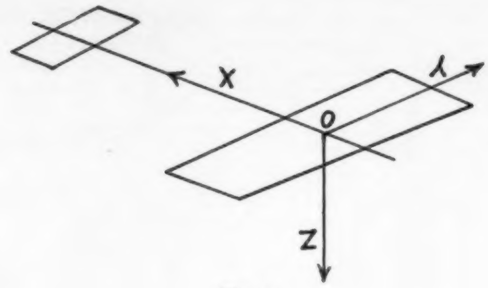


Fig. 6.

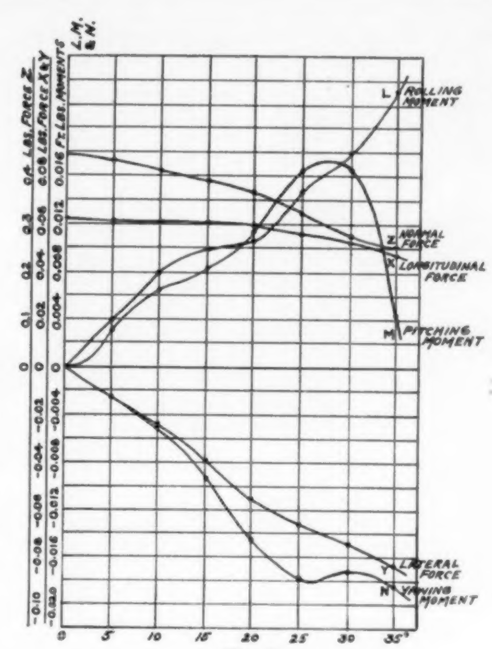


Fig. 8.

great success. The forces on an aerofoil are the resultant of the pressures due to the wind at all points of its surface. If these pressures be measured at a sufficient number of points, the pressure distribution can be plotted and the resultant force calculated. This has been done and the results are shown in Fig. 5, where the values found by calculation are compared with those measured directly.

In the case of the lift, the agreement is complete; in the case of the drift it is less good, the calculated results are generally too low, and this would be expected, for in the calculation the air friction on the surface has been neglected. This would hardly affect the lift; it would modify the drift and the ratio lift-drift considerably.

Reference may, perhaps, be made to another result which follows from the plotting of the pressures and to which attention has frequently been called. A very much larger proportion of the upward lift is due to the reduction of pressure on the upper side of the aerofoil than is caused by the increase of pressure on the lower side; thus, in designing a wing the shape of the upper surface is much more important than that of the lower.

THE STABILITY OF AEROPLANES.

Let me turn now to some further developments of the model experiments. The theory of the stability of an aeroplane has been developed by Lanchester, Bryan and others, and is very complex. It depends on finding an expression for the energy of the machine in any position in terms of the velocities of its center of gravity along the axes of reference and of the angular velocities of the machine about these axes. This expression involves a number of constants, quantities which depend on the shape and dimensions of the machine, not on its motion. If we know the energy, values can be found for the forces and moments on the machine—these involve the same constants—and the equations of motion can then be formed. Their solutions can be obtained at any rate in certain cases of importance, but to utilize the results we require to know the numerical values of the constants just referred to, and to determine these we must have recourse to the model experiments. By means of the balance, the forces on the model can be measured; these forces can also be expressed, as we have seen, in terms of the constants, and the wind velocity, and hence we can find certain of the constants applicable to the aeroplane considered.

Further experiments of a somewhat different character are required to determine the values of the rest of the constants or coefficients in the energy expression—the rotary derivatives, as they are called; but by means of the model experiments all these can be found, and on substituting the values in the equations of motion, the nature of the motion can in many cases be determined by the solution of the equations.

DETERMINATION OF STABILITY COEFFICIENTS.

The next series of figures give some of the results of this work. A model of an ordinary type of monoplane, such as is exhibited, is supported in the channel in various positions relative to the direction of the air current and the forces measured; the axes or direction of reference are taken as shown in Fig. 6. The axis of x is along the length of the machine from head to tail, in the direction which is horizontal during the normal horizontal flight of the machine and opposite to the direction of motion. The axis of z is at right angles to this in the plane of symmetry of the machine, while the axis of y is at right angles to the two, parallel, that is, to the length of the wings.

PITCHING, ROLLING AND YAWING.

We use the term "to pitch" to mean the angular motion up and down in the plane of symmetry, turning that is about the y axis; "to roll" or bank, to mean rotation about the length of the machine, that is about the x axis, and "to yaw" to turn to right or left about the axis of z. The angle of pitch is positive when the nose of the machine rises, the angle of yaw is positive when the machine turns to the right, and the angle of banking which properly accompanies this turn to the right will also be positive.

Fig. 7 gives the forces and moments which are produced in the plane of symmetry when the attitude of the machine to the wind changes, but without yawing, while in Fig. 8 are shown the forces and moments produced by yawing without altering the angle of pitch, so that the flight is horizontal. The wind speed for which the forces are given is 30-foot seconds.

Starting from zero pitch angle the longitudinal force falls as the angle of attack is increased, reaches a minimum at about 8 degrees, and then rises again rapidly. The normal force increases regularly as the angle of attack increases, while the pitching moment increases in amount but is negative, that is to say, it tends to reduce the angle of attack.

The machine is stable longitudinally, so far as pitching moment on it is concerned, but further investigation is required before the motion can be completely determined.

Turning now to Fig. 8, we see that as the angle of yaw increases the longitudinal and normal forces are somewhat reduced, though the changes are not at first large, but a considerable negative lateral force is brought into action, if the machine turns to the right the side force is from left to right, the machine side-slips in the direction in which it is turning. There is a yawing couple N which is negative, i. e., tends to reduce the angle of yaw and turn the nose of the machine into the wind, at the same time a positive rolling moment L is produced, the machine tends to bank as required for the turn, and also at first we have a positive pitching moment M, the angle of attack is increased, and the nose of the machine rises.

The next figure, Fig. 9, gives the curves of pitching moment of a biplane model for various settings of the elevator in the tail, the wind speed in this case being 40-foot seconds. Without the tail plane the angle of attack for horizontal flight would be slightly negative, but the machine in this state would be unstable, any increase or decrease in the angle of attack causes a moment tending still further to increase or decrease the angle respectively and so to disturb the machine. With the tail plane the machine flies though with no great longitudinal stability when the elevator is not raised. The effect of raising or lowering the elevator is shown in the curves. Positive angles correspond to an elevation of the elevator tending to raise the nose of the machine.

THE WASH FROM THE MAIN PLANES AFFECTS THE TAIL.

As the result of experiments of this kind, it appears that the effect of the tail on the longitudinal balance is much less than would be anticipated, if it is supposed that the air current is not deflected by the planes of the machine and is free to act on the tail as though the main planes were absent. The wash from the main planes reduces the moment on the tail very greatly. This is shown in Fig. 10, which gives in the upper curve the moment about the center of gravity of the machine as calculated from a knowledge of the shape and position of the tail, the elevators being at a small positive angle. The lower curve gives the measured moment, which is of about only half the amount.

To account for this, observations were made with Pitot tubes of the distribution of velocity round the tail, and the middle curve—marked calculated effective tail—was obtained from these. The difficulty of the measurement accounts probably for the outstanding difference, but the matter is still under investigation. As a result, we find that an alteration of the inclination of the machine to the wind produces an alteration of only about half the amount in the direction of the wash from the planes, and thus causes much less change in the moment due to the tail than would be anticipated from the change in attitude of the machine. The matter is of importance and requires further study to determine the best position for the tail.

(*To be continued.*)

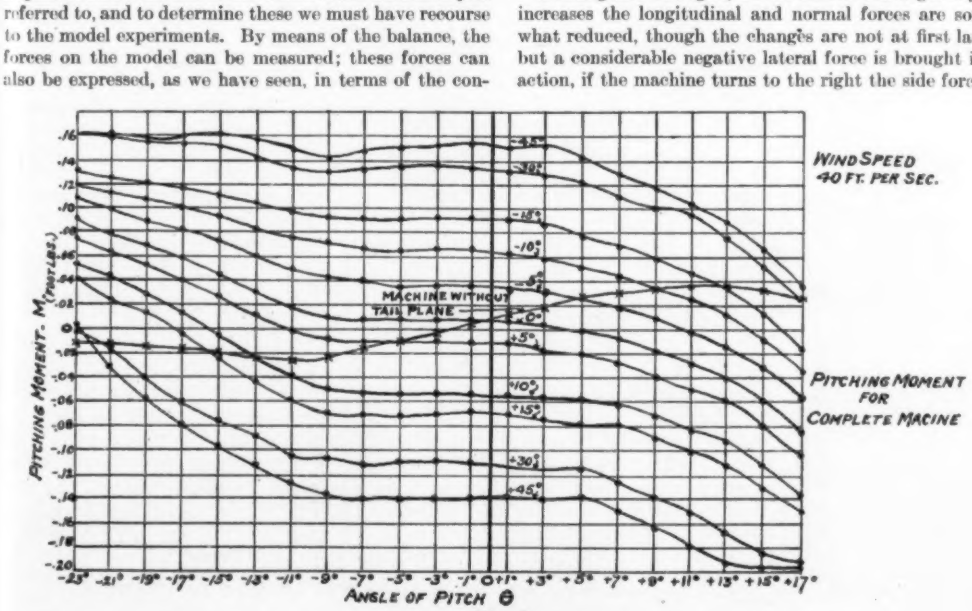


Fig. 9.

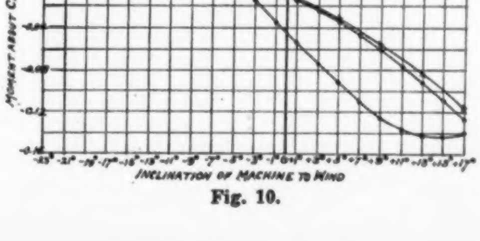
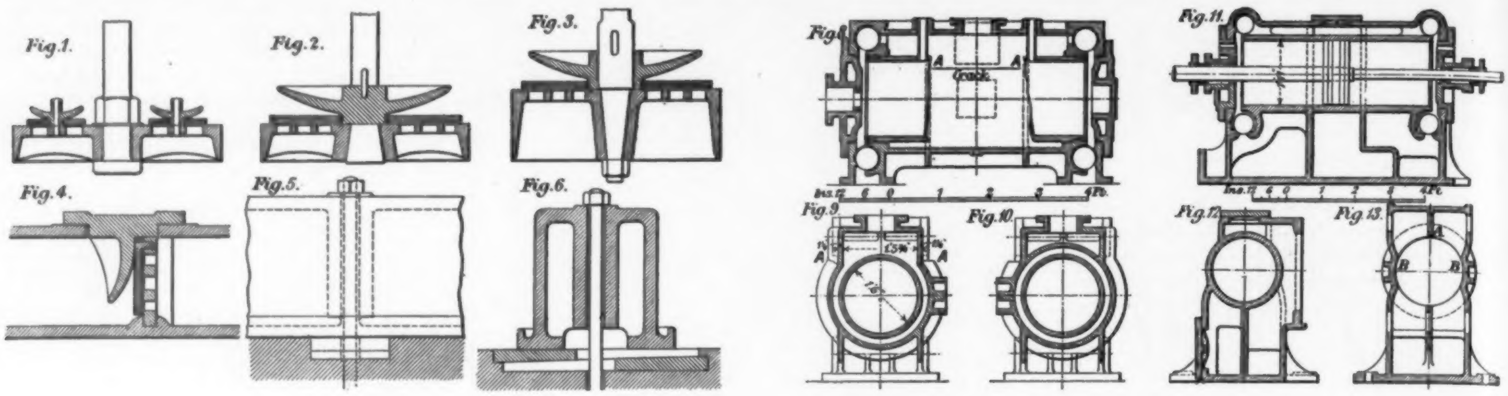


Fig. 10.



Breakdowns of Stationary Engines*

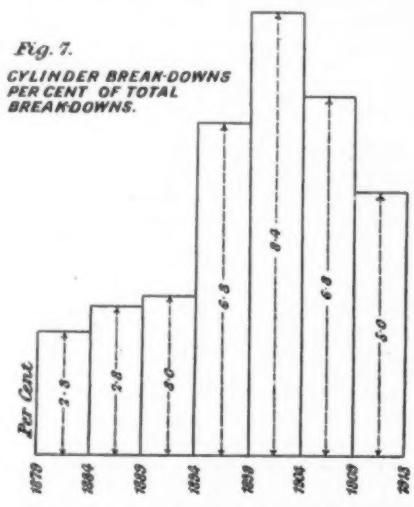
Causes Originating in Various Parts of the Machinery

By Michael Longridge

"Breakdowns of Stationary Engines" is rather a sensational title for a lecture, and it is possible that some may have come here expecting a more exciting story than I am prepared to tell. That such may not depart entirely unsatisfied, I will begin by referring to the bursting of the fly-wheel of a pair of horizontal compound engines, indicating about 400 indicated horse-power, and transmitting that power to a weaving-shed by a spur fly-wheel hung upon the crank-shaft. Both cylinders had Corliss valves. On the morning of the accident, the engine started at 6 A. M., and ran as usual till about 7 A. M., when it began to race. The operatives threw off their looms and ran. The engine-man and another man rushed to the engine-house, and with conspicuous bravery made for the stop-valve, which, as usual, was placed between the two cylinders, in a direct line with the fly-wheel. Before they could close the valve, possibly before they reached it, the fly-wheel burst, and both were killed. Some of the flying masses cut the traveling crane in two and unroofed the engine-house. Others cut through the wall of the engine-house and ploughed a path of destruction into the weaving-shed, unfortunately injuring four of the weavers who had been unable to escape. The fly-wheel arms were snapped off short, at their junctions with the boss, and a large piece was torn out of the boss itself, the pinion was broken, and the second-motion shaft—a heavy shaft, 8½ inches in diameter—was dragged from its fixings and bent. The engine foundations were dislocated, and the engines themselves moved bodily from their places. Fortunately the cranks and connecting-rods remained connected, and the cylinders were saved, but all the valve-gear was smashed, and the bed-plate of the condensing engine was badly cracked.

* Lecture delivered before the Graduates' Association of the Institution of Mechanical Engineers, on Monday, February 9th, 1914.

When the wreckage had been cleared away sufficiently to allow access to the engines, I examined them. I found the governor, the wheels which drove it, and the knock-off gear in order. The front steam-valve of the high-pressure cylinder was open, and the spring in the front end of the dashpot, which should have closed it, was compressed

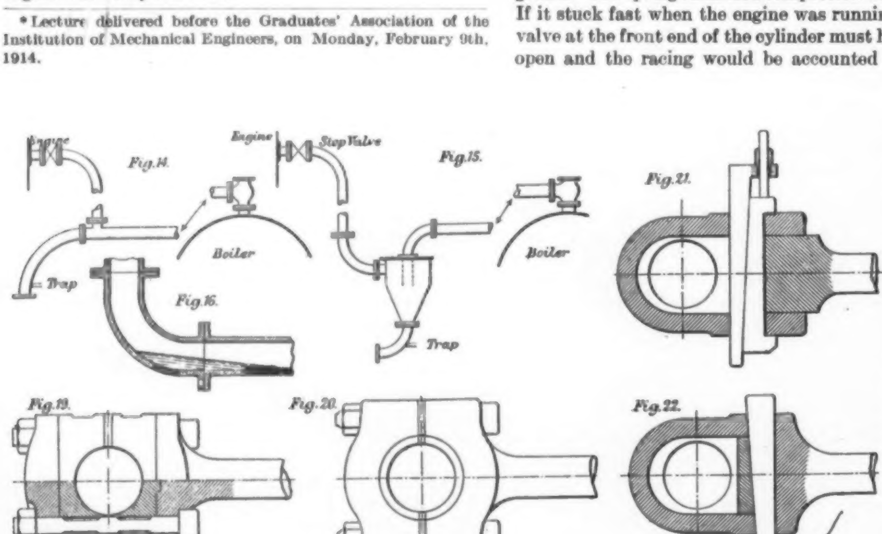


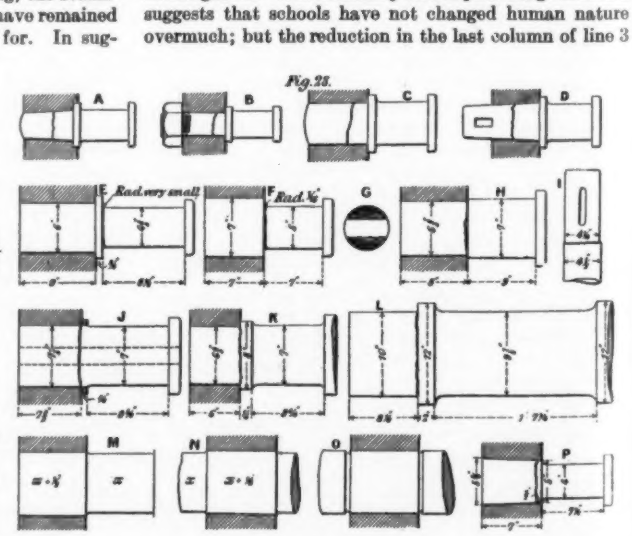
and cemented coil to coil, and to the walls of the dashpot, by a viscous brown cement consisting apparently of baked grease. The spring remained compressed when taken out. If it stuck fast when the engine was running, the steam-valve at the front end of the cylinder must have remained open and the racing would be accounted for. In suggesting this as an explanation of the breakdown, however, I should mention that the consolidation of the grease about the dashpot spring may have been due to cold, for, owing to the destruction of the engine-house roof and wall, the engines had been exposed to very cold weather for several days before I saw them. The cause of the breakdown, therefore, is uncertain.

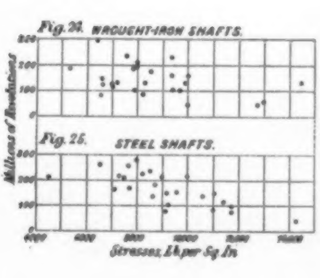
In another mishap of a similar nature, the wreck was too complete to leave any clue to the cause. Fortunately, smashes so complete are the exception, not the rule. Of 71 breakdowns in 100 the cause can be discovered. The table herewith shows the number of breakdowns attributable to each of four groups of causes, as percentages of the total breakdowns during three consecutive periods of ten years.

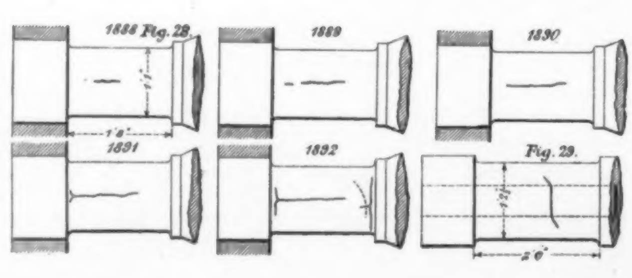
Cause of Breakdown.	1881 to 1890.	1891 to 1900.	1901 to 1910.
	per cent	per cent	per cent
1. Accidents and causes not ascertained	36	27	29
2. Negligence or ignorance of owner or attendants	19	22	19
3. Structural weakness, bad designing or workmanship	30	30	21
4. Old flaws, defects, or wear and tear	15	21	31
Total	100	100	100

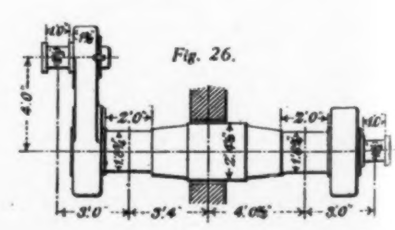
The classification is not very satisfactory, because it is without clear lines of demarcation. It was begun many years ago and could not afterward be altered without much labor. But if the figures are not very accurate, their meaning is quite clear. Those in line 1 call for no remark, except that the high percentage in the first decennial period is principally due to want of opportunity for investigation. The constancy of the percentage in line 2 suggests that schools have not changed human nature overmuch; but the reduction in the last column of line 3











awakens hope that the vast sums spent on technical education have not been altogether wasted; and, if we take the figures for each of these ten years separately, hope changes to conviction, for we find the percentage falling more or less regularly from 23 in 1901 to 16 in 1910. If more evidence be wanted, it is given by line 4,

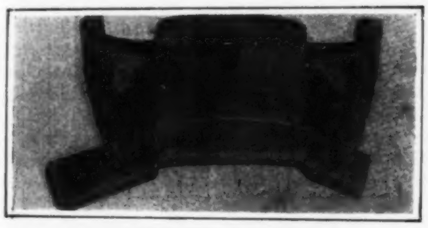


Fig. 17.—Piston-rod breaks occur at the cotter holes.

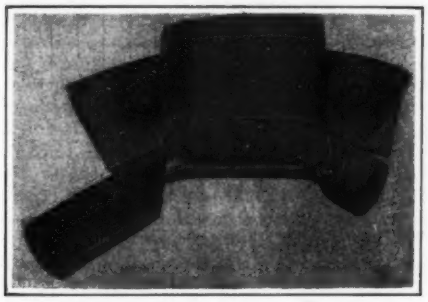


Fig. 18.—Another example of piston-rod break.

which by comparison with lines 2 and 3 reveals how work and age are year by year supplanting ignorance, neglect, bad workmanship, and bad design as causes of breakdowns of steam-engines. I do not mean to say that improvement in design only began ten years ago, but it was gradual. The substitution of the principles of mechanics and arithmetic for rule-of-thumb was slow, and the replacement of old engines by new was slower still, so that years elapsed before the effects of the change became appreciable. But if progress was slow, it was effective. When I began to collect statistics 34 years ago, engines running for the most part 50 to 60 hours per week broke down, on an average, once in 5½ years; now, though speeds and pressures have been doubled, they break down once in 9½ years. That is what we older men have done. Those who are taking our places are expected to do more; and if it will lighten your task to start it with some knowledge of the casualties from which the several parts of steam-engines most commonly suffer, I am here to tell you all I can in the time allotted to me.

Valves and Valve-Gears.—I begin with valves and valve-gears, because at the present time they fail more frequently than other parts of steam-engines. About one third of the total number of breakdowns originate in them. The proportion has nearly doubled in the last 35 years. It has increased concurrently with the use of Corliss and other complicated automatic trip-gears, made up of many pieces. Many of those gears are too weak for the abnormal stresses to which all valve-gears are occasionally exposed; but a large proportion of the breakages is due to failures of the screws, bolts and keys, by which the parts are held together. Many breakages of valve-gears cause little damage, but some have very serious results. Most "runaways" are due to failure of valve-gears or governor-gears controlling them. Every engine, therefore, ought to have a "knock-off" gear acting on the stop-valve or a special runaway valve. Electric gears which can be operated by pressing a button in any part of the works, as well as by the knock-off motion on the engine, are the best. Valves intended to be closed by springs should be actuated by gears which will close them if the springs should fail, as seems to have happened in the breakdown I first mentioned. Not a few breakdowns are caused by eccentrics slipping or becoming disconnected from valves, leaving the one or other of the cylinder ports permanently open or closed. When this port is a steam-port of a high-pressure cylinder, a runaway may follow; when it is an exhaust port, the compression curve may run up high enough to blow off the cylinder end. When the inlet to the low-pressure cylinder remains closed, the pressure in the valve-chest, or receiver, may rise sufficiently to burst one or the other. All these things have happened, and the only preventatives I can suggest are large safety-valves, ferruled to prevent overloading, not only on the cylinder ends, but on the receivers, or pipes, between the cylinders.

Air-Pump Motions, Valves and Buckets.—After valve-gears, the parts which fail most frequently are air-pump motions, valves and buckets. They accounted for 20 per cent of the engine breakdowns 30 years ago. They still account for about 16 per cent, and yet some trouble on the part of engine-tenders, and a little thought on the part of engine-builders, would enormously diminish the number of mishaps. The cause of half of them is corrosion and neglect. Neglect is almost pardonable when one considers the dark, dirty, inaccessible holes in which air-pumps are so often placed. Corrosion is to be expected, and should be circumvented by putting neither bolts, nuts, screws, rings, valves, nor guards inside the pump. There are both vertical and horizontal air-pumps on the market which can be made without a single fastening inside. If you must use the old-fashioned vertical pump, put no rings in the bucket; water-sealed buckets need not be tight. I have known two plain buckets, ¾-inch less diameter than the pumps in which they worked, giving 10 pounds vacuum in the cylinder.

Secure the bucket and guard against a collar or cone on the bottom of the rod, by a nut or cotter on top, as in Figs. 1 and 2, instead of tapering the cone downward and putting the nut below the bucket, as in Fig. 3, to drop off and allow the bucket to fall into the foot-box. Slide the foot-valve grid into grooves in the foot-box, and cast the guard upon the foot-box cover, as in Fig. 4, so that there may be no bolt to corrode and break. If the pump be horizontal, the bucket will not be water-sealed, and the piston must either be renewed when it has worn down, or fitted with a ring. The piston, being a plain disc, can be screwed and shrunk on to the rod. Do not use combinations of brass and iron. If the water be at all acid, a brass-sheathed rod will be cut through, where the sheathing ends, as with a knife. Avoid trunk motions. The screw of the eye at the bottom of the trunk will suffer from corrosion, and the pin from grit. Every trunk motion I have had to deal with has broken down at least once. Finally, pay great attention to all fastenings; put the air-pump in a light, accessible place, and if there be any doubt about the free flow of the water from the hot-well by gravitation, make the motion fit for a pressure of at least 50 pounds per square inch on the bucket.

Bed-Plates.—Breakages of engine-frames and bed-plates can be dismissed with a very few words, because

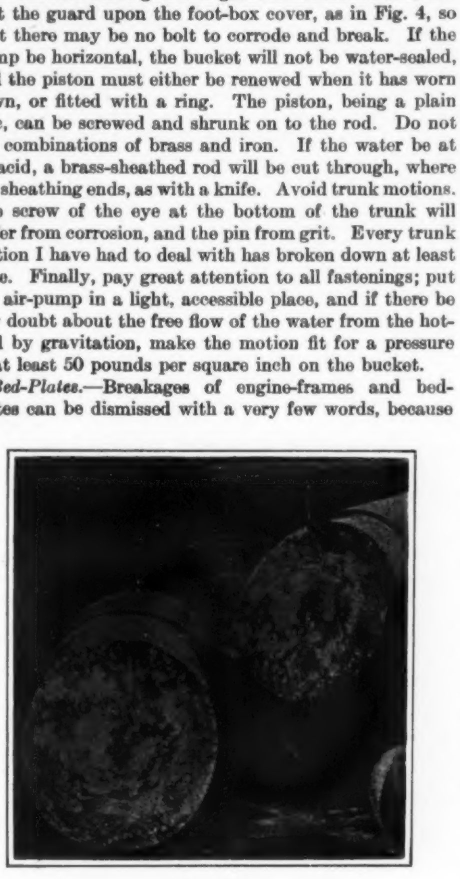
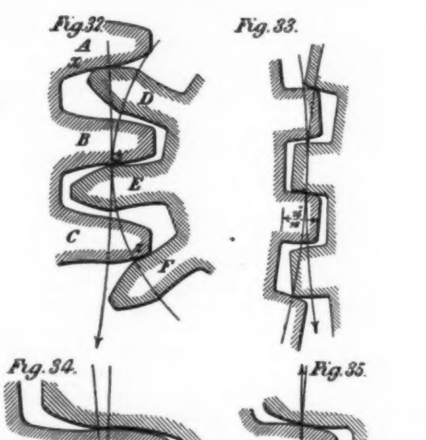


Fig. 27.



by far the largest number are caused by the pounding of the engines, or by wringing up holding-down bolts, after the seats below have been softened by oil. It is true that, with modern systems of lubrication and oil recovery, very little oil should reach the seat, but it is equally true that the modern practice of setting down an unplaned bed-plate in a rough lump of concrete, packing it level with any bits of iron that may be handy, and grouting it with cement, provides so little material to resist the oil that the grouting ceases to give adequate support even sooner than did the old ashlar seats with gallons of oil poured over them each week. The consequence is that breakages of frames, bed-plates, and the like, still bear as large

Fig. 30.—Piece cut from steel shaft after break.

Fig. 31.—Piece from same shaft magnified four times.

a proportion to the total breakdowns as in the early eighties—namely, about 7 per cent. It is quite easy to keep engine-seats free from oil, and dry. All frames and bed-plates should have channels round the feet, as in Fig. 6, troughs under the ends of all bearings, or, when there is only a top and bottom brass, shields like those on the bearings for the shafts of dynamos and motors. The bed-plates of vertical engines of the marine type should have the bottoms of the crank-pits cast with them.

Where a bed-plate is to rest on ashlar, it should be planed on the underside, and rubbed to a perfect fit upon the dressed surface of the stone. When it is to rest on concrete, the bottom surface, which is to be supported by the cement grouting, should be as wide as possible, instead of a strip a few inches wide along each side; and holes should be arranged at intervals for running the cement into the space between it and the concrete seat. In my opinion, it is best to plane the underside at each holding-down bolt, and level the bed-plate upon a pair of broad machined folding-wedges at each bolt-hole, as in Figs. 5 and 6.

Cylinders should not be placed on concrete, but on iron frames or plating, according to their shape. This plating should have holes for running cement between it and the concrete seat, and there should be raised rims round these holes, round all openings for pipes, and round the edges, to retain oil and water; also machined facings for the cylinder feet to stand on, so that they may slide when the cylinders expand. Horizontal engines should be firmly held to the seat at the crank end, but the cylinder end should be free to slide. Never tighten a holding-down bolt till the superincumbent weight has been lifted from the bed-plate, and the space below it, if there be any, carefully packed.

Cylinders.—In old days, breakages of cylinders were generally due to water or stray piston-bolts; now the majority are caused by water or structural weakness. The diagram, Fig. 7, shows plainly what has happened. The abscissæ represent successive periods of five years from 1879 to 1913, the ordinates the breakages of cylinders, as percentages of the total number of breakdowns, in each quinquennial period. The year 1883 may be considered as about the end of the old time, when 80 pounds was a high pressure, and a tallow kettle simmered on the cylinder. About 1890, steam of 160 pounds pressure began to be used in mills, and many old cylinders, reduced in diameter by liners, were supplied with it regardless of weakness of ends and valve-chests. Also many of the new cylinders made about that time were too weak. The curve shows how breakages increased, and subsequently decreased as the new conditions were met by improved designs.

Before referring to some of the faults of design which provoke fracture, I would like to remind designers of cylinders and other parts that deformation, or strain, induces stress. It is often an advantage to consider what deformation would occur in the thing they may be designing if it were made of India rubber. Figs. 8 and 9 show a cylinder made in 1894 for a pressure of 120 pounds per square inch. It worked for 8 years at that pressure, then for 18 months at 140 pounds, and finally for 6 months at 160 pounds, when the two longitudinal cracks AA, Figs. 8 and 9, were found. Regarding the cylinder as made of

India rubber, it would be seen at once that the two sides of the upper part of the jacket, Fig. 9, would be forced outward, and bending would occur just where the cracks appeared. Even if the outer cylinder were complete, as in Fig. 10, the steam-passage would be a source of weakness, because its bottom surface, having the same pressure on both sides, would flatten out and allow the same kind of deformation as before. The flat top of the steam-passage, Fig. 9, was also weak, and would probably have cracked along its longest edges in course of time, for the stress calculated by the formula for flat surfaces:

$$f = p \times \frac{b^2}{2\,t^2} \times \frac{l^4}{l^4 + b^4}$$

given in Unwin's "Machine Design" was 16,000 per square inch.

In good designs, I have found f to lie between 3,000 and 8,000 pounds. The wide variation is not surprising when one considers how much the strength of castings is affected by shape and crystallization during cooling. In dealing with castings, experience is the only safe guide, though for purpose of comparison a formula may be useful as a rough criterion.

Figs. 11 to 13 show the high-pressure cylinder of a triple-expansion engine, made five or six years later, for a boiler pressure of 160 pounds, and a pressure of 70 pounds in the receiver between it and the I. P. cylinder. Soon after it was set to work, it cracked through the bars across the ports A, Fig. 13, and then from the corners B of the ports. It was replaced by another of the same design, which quickly failed in the same way. Here there was a load upon the end of 92 tons during admission and 52 tons during exhaust. If the cylinder had been rigid and the load distributed uniformly over the cross-section of the metal, the stress would nowhere have been excessive; but with a cylinder of India rubber, it is easy to see how a large part of the load would be concentrated on the bars across the ports, and how, on their failure, the deformation of the end would intensify the stresses at the corners of the ports. Also deformation of the barrel from a circular to an oval cylinder would be caused by the external pressure on the top and bottom, and the absence of an equal external pressure on the sides. This deformation is sometimes sufficient to make well-fitting pistons seize.

Finally, passages cast round cylinders, whether for live steam, as in these figures, or for exhaust, frequently originate circumferential cracks in the barrel, owing to the unequal expansion of the metal inside and outside them. They are also likely to cause sponginess where the walls join on to the barrel. The design is not one to be copied, and I cannot but suspect that if the draughtsman had kept the India rubber model in mind when he was drawing it, these cylinders would never have been cast.

The usual way of strengthening the ends of cylinders is to lengthen the distance between the ports and the end flanges, and then to lengthen the spigots on the cylinder-covers, to fill the increased clearance spaces. Unfortunately the clearance surface at each end of the cylinder is thereby increased by two rings, each equal in area to the circumference of the cylinder multiplied by the length of the spigot—rather an important disadvantage when saturated steam is to be used, and guarantees of steam consumption are required. Of course, it is possible to suppress the surface by making the spigot fit the cylinder, but then it is extremely difficult to get the cover off; or by making the joint at the surface of the spigot next the piston, but that may be as dangerous to the cylinder and cover flanges as a ring of jointing material placed entirely inside the bolt circle, unless special precautions, which I cannot now describe, be taken. The practical alternative seems to be to make the space so narrow that, when it is filled with water, the surface of the water presented to the steam in the cylinder will be so small that the condensation and evaporation will be negligible. The late Mr. Bryan Donkin made some experiments for me to determine how narrow the space would have to be, and he told me that under most conditions a difference of 1/16-inch in the diameter of cylinder and spigot would probably suffice to keep the space filled with water and the surface inactive. His experiments were made with clean steam; with oily steam, the space might possibly be increased, because the fluid filling it would be more viscous than pure water.

If the bell-mouth and spigot be bored and turned slightly conical, and to fit each other when there is no jointing material between the flanges, then, when the jointing material is put in, the water space will be very narrow, but will widen rapidly as the cover is being drawn off. When the bell-mouth is very short, deformation, and local stress at the corners of the ports, may be reduced by bolting a deep cover, like a short cylinder with its two flanges tied together by ribs between the bolt-holes, to the cylinder flanges. The difficulty of designing cylinders for high pressures and temperatures is much enhanced by attempting to combine valve-chest, steam and exhaust passages, and cylinder in a single casting. It is far better to make cylinders plain tubes, or plain tubes with nozzles near the ends, and to carry the valves in suitable gable ends, cylinder-covers, or valve-chests bolted to the flanges on the barrels. The arrangement allows the barrel to be made of hard metal, giving an index number of about 40 when tested by Shore's scleroscope; while the more complicated castings, containing barrel, valve-chests, and passages, cannot be made with metal giving a higher number than about 36. Moreover, the distortions produced by temperature, and by the growth of gray cast irons under temperatures as low as 500 deg. Fahr., imperatively demand the very simplest forms.

Damage by Water.—Leaving cylinder design, I now wish to say a few words about breakdowns from water. Water is seldom carried over from boilers in sufficient quantity to cause damage when steam-pipes are properly laid, as shown in Figs. 14 and 15, with a continuous fall from the boiler junction-valve to a well-pipe or separator near the cylinder, and a continuous rise from the separator to the engine stop-valve, which should be at the highest point of the pipe, and as near to the cylinder as possible. Pipes with vertical bends, Fig. 16, are apt to harbor water when only a light breeze of steam is blowing through them, and this water is carried forward in gulps when the breeze becomes a hurricane. But even these gulps seldom do damage except when they get into the upper ends of vertical cylinders, the exhaust ports of which are shut before the end of the up stroke, or into horizontal cylinders with the exhaust-ports on the top. Generally the water causing breakdowns comes from jet-condensers, when an engine is running slowly, and the injection cock has not been shut, or the vacuum destroyed. The flow into a jet-condenser depends upon the vacuum therein, the flow out of it upon the speed of the air-pump; and it may easily happen, when an air-pump is running slowly, that more water may enter the condenser than the air-pump can discharge, in which case the excess first fills the exhaust-pipe and then runs into the cylinder. For this reason, when the air-pump is driven by the main engine, the vacuum should always be destroyed by letting air into the condenser before beginning to shut off steam; and when it is driven by an independent engine this engine should be started before, and stopped after, the main engine. It is often extremely interesting to discover how water has got into a cylinder, but time will not permit of going into this point now in further detail.

Pistons and Piston-Rods.—Previous to 1899, breakdowns originating in pistons averaged 2.5 per cent of the total breakdowns. Since then, the average has been 4.8 per cent. The rise came suddenly soon after the rise of steam pressure to 160 pounds, but I do not know that there is any connection between the two. During the last three years, 47 per cent of these breakages have been caused by stray screws, or bolts, or broken rings, 17 per cent by water, and the rest in various ways. When the substitution of plain pistons, with cast-iron rings sprung into grooves, for pistons with junk-rings and fancy packings is complete, breakdowns from piston breakages will be halved.

Breakages of piston-rods occur nearly always at the cotter-holes at the crosshead end, and are due to concentration of stress at the edges of the cotter-holes, as explained by Dr. Unwin on page 223 of Part II of his "Machine Design," 1912 edition. I endorse his explanation, and Figs. 17 and 18 afford convincing proof that cotters do bend in the way indicated by the drawing in his book. These figures are from photographs of two pairs of folding-wedges from the piston-rods of two old beam-engines after exhibitions of water in the cylinder. I would have shown single cotters, such as are generally used, but I, unfortunately, have none by me at the moment; moreover, I am not sure that folding-wedges are not preferable to single cotters, because a piece with parallel sides is easier to fit accurately than a tapering wedge; but if they be used, it is clear that the position of the pieces shown on the screen should be reversed, the broad piece should bear on the rod, and the narrow on the crosshead.

Connecting-Rods.—Fractures in connecting-rods occur generally at the ends which couple the rods to the crank-pins, or crosshead centers; sometimes in the forks, when the crosshead ends are forked; and rarely in the bodies of the rods.

The commonest types of end are: the box or closed eye, Fig. 22; the open strap secured by gib and cotter, Fig. 21; and the marine end with cap and bolts, Figs. 19 and 20. Of the three, the marine end, Figs. 19 and 20, is, in my experience, the least safe, because of the frequent breakages of the cap-bolts, usually at the junction of the head and shank, or at the screw thread. The principal causes of these breakages are: repetitions of stress or blows, abrupt changes of form, cross-bending stresses produced by the inertia of the rods. The antidotes are: for the first, probably spare bolts, to give alternate periods of rest and service. Annealing is risky in unskilled hands. For the second, large fillets at junctions of heads and shanks, gradual reductions of diameters in shanks, and threads with rounder roots than the British standards; but fillets, cones, etc., at changes of section must be very neatly finished where they merge into the cylindrical parts, and threads very carefully chased, especially in steel, to leave nothing in the nature of cuts or scratches to initiate cracks. Also stiffer palms and caps are often needed to prevent deformations, which would be apparent on reference to an India rubber model, and consequent concentration of stress on one side of the bolt.

For the third, bolts with *areas* instead of *diameters*, approximating to half those of the rods and the substitution of jaws, Fig. 20, long enough to hold at least one of the brasses, for palms, Fig. 19. Rods like Fig. 19 should be taboo, for it is easy to imagine the effect of a cross-bending stress if there be any wear or slackness. Bolts of small engines are more heavily strained by this stress than large, because the ratio of their length to their diameter cubed is greater. For connecting-rod bolts wrought iron is a safer material than steel. Open straps, Fig. 21, secured by gibs and cotters are but little safer than marine ends. The jaws of the cotters wear, the straps open under the cross-bending stress produced by the inertia of the rod, and break, generally through the oil-hole. Fracture almost invariably begins on the inside surface, and when it has extended a certain distance, often not far enough to be visible above the flange of the brass, the strap breaks and opens out. Never trust a strap till you have seen the inside surface. Open straps should be kept closed on the butts of the rods by bolts, in place of, or in addition to, the gibs.

Of the three forms, the box end, Fig. 22, is undoubtedly the most reliable. Fractures, when they occur, usually commence, as in the straps, on the inside surface at the hole for the lubricator, but extend slowly enough to be discovered before the rod gets free. Among more than 6,000 breakdowns of engines of various kinds I can only find one where fracture of a wrought-iron or steel box-end caused damage to an engine, and this was the fault of the engine-tender, for the fracture had been visible on the outside surface of the end as far as the lubricator-hole some time before the rod gave way.

Crank-Pins.—The history of crank-pins has been very like that of cylinders, showing a rising percentage of breakages, culminating in the five years 1894 to 1898, and then falling. The rise was due to bad designing, improper methods of fixing, and over-loading; the fall to the more general adoption of the right method of fixing, combined with reduction of stress. In my early days, stresses of 12,000 to 14,000 pounds per square inch were common, and stresses of 50 per cent higher were frequently met with. Samples of the old designs and methods of fixing are shown in Fig. 23. In Fig. 23, A, B, C and D are examples of pins with conical or cylindrical shanks fitted into the cranks and secured by riveting, screws and nuts, or cotters. They usually broke inside the crank-eyes, because the fit was not accurate enough to prevent slight movements, which wore and enlarged the ends of the crank-eyes next the journals, thus throwing back the point of support and increasing the bending moments. It will be noticed that the pins were usually put in from the faces of the cranks, so that they could come out and wreck the engine when they broke. E and F are also typical examples. They have not sharp corners at the junctions of the journals with the collar, though such were not unusual; but the fillets provided, 1/16-inch to 1/8-inch radius, are too small to be effective. Both pins were of steel. The fractures were due to bending stresses. They commenced at the parts of the circumference nearest to, and farthest from, the crank-shaft, and extended inward as shown on the shaded part of G, Fig. 23. The lives of these pins were 14½ and 104 million revolutions, and the bending stresses 17,500 and 11,500 pounds per square inch respectively.

The breakage of H may have been entirely due to the abrupt change of diameter from 6¾ inches to 7 inches, for piston-rods in direct tensile stress will break with a smaller change than is shown in I, Fig. 23; but probably it was started by the shearing action of the edges of the crank-eye, when cooling and contracting upon the pin. The failure of the pin J can be attributed to nothing else but shear. It was made of steel, of 60,000 pounds tensile strength, 29½ per cent extension in 6 inches, 60 per cent contraction of area, and a strip, cut out of it after the breakdown, was bent cold nearly double without cracking. It broke under a stress of 9,400 pounds per square inch, after 5¾ million revolutions. I think the crank-shafts K, Fig. 23, and L are similar cases. The stresses and lives were: for K, 8,200 pounds per square inch and 17 million revolutions; and L, 5,000 pounds per square inch and 218 million revolutions; the longer life of L was due to the lower stress, and probably to a lower pressure exerted by the crank in cooling. I do not think the effect of the pressure of sharp edges, or even of scratches in starting skin-cracks in steel, or the almost inevitable extension of such cracks under recurrent stresses, is sufficiently appreciated. About scratches, I shall say a few words presently. Of shrinkage, I say, without hesitation, that the portion of the internal piece upon which an external piece is to contract should be of larger diameter than the adjacent portions, and that the external piece

should entirely cover the enlarged portion of the internal. *M* Fig. 23, shows how a crank-pin should be put in, while *N* and *O* show the proper method of shrinking a piece upon a shaft. It is to the adoption of this principle by many engine-makers, combined with reduction of working stress to 8,000 pounds or 9,000 pounds per square inch, that the reduction in the number of crank-pin breakages must be attributed. The failure depicted in *P* is one of those things "no feller can understand."

Crank-Shafts.—The majority of mill-engines have plain shafts with overhung cranks carried in two bearings. In 1879, these shafts, except a few old ones of cast iron and a few new ones of steel, were of wrought iron. Now nearly all are of mild steel. I think most of the breakages may be ascribed to gradual disintegration by wear and tear, and vibration of spur-gearing, or to the extension of small flaws or cracks existing in the interior of the shaft when new, or developed upon the surface afterward by chilling it when hot. The duration of life measured in revolutions of the engine undoubtedly bears some relation to the stress, but it is uncertain what this relation is. I have been able to get fairly reliable information about a certain number of broken shafts, and from it I have plotted the points shown on the two diagrams, Figs. 24 and 25. Fig. 24 refers to wrought iron, Fig. 25 to mild-steel shafts. In both, the abscissæ represent stresses calculated by Rankine's formula, and the ordinates length of life in millions of revolutions of the engine. Beyond a general tendency to abbreviation of life by increase of stress, the spots show nothing, and I fear the effects of repetitions of stress are here, and in similar statistics always will be, obscured by the other causes of breakage I have mentioned, and the difficulty of getting accurate information about shafts which have worked for many years.

I would like to describe a few breakages of crank-shafts. The first case is one of the disintegration of a cast-iron shaft by wear and tear. The dimensions of the shaft are shown in Fig. 26. It belonged to a pair of beam engines, and was put in, with them, in 1850. In 1900, there were several slight longitudinal cracks in both necks, and in the left-hand neck one 14 inches long, which was said to have been visible for 20 years. On April 7th, 1910, this neck got hot, and the mill had to be stopped to allow it to cool. On April 8th, it ran hot again, and was examined in the evening, when, besides the 14-inch crack, 24 other well-defined cracks of various lengths, up to 5½ inches, were visible, all longitudinal in direction and situated near the middle of the bearing. It then transpired that the neck had been hot in 1908, and had been cooled with water. It was therefore doubtful whether the cracks were more than surface cracks caused by the water; but having regard to the age of the shaft, its replacement was advised. The decision was justified when the shaft was broken under the tup. The fracture surfaces, shown in Fig. 27, did not coincide with any of the longitudinal superficial cracks, but were transverse and diagonal. The new and white fractures were caused by the tup, while the dark old fractures, blackened by oil, were very considerable in extent, and showed the disintegration of the interior of the shaft by age and wear. The right-hand neck showed similar black and white areas when broken. Some particulars of the life of the shaft, so far as they could be ascertained, may be of interest:

	1850 to 1873.	1873 to 1897.*	1897 to 1910.
Millions of revolutions	70	76	41
Initial load on piston (in pounds)	90,000	56,500	51,000
Bending stress on neck (pounds per square inch)	3,650	2,270	2,050
Load on piston at cut-off	76,500	36,800	33,960
Bending stress equivalent to bending and torsion by Rankine's formula (pounds per square inch)	3,750	1,930	1,580

* Mill stopped one year during this period.

Total life, 187,000,000 revolutions. Average stress, 2,700 pounds per square inch.

Fig. 28 shows the gradual destruction of a wrought iron shaft 28 years old, during the last 4 years of its life. The first crack, probably the opening of a cinder mark or imperfect weld in the forging, was seen in the left-hand neck in October, 1888. The development during the following 3 years is shown in the figure. In 1892, it had farther extended, and there was also another crack in the right-hand neck, of the development of which I have no record. The cracks shown by the full lines are on the part of the circumference farthest from the crank-pin, those shown by the dotted lines on the part nearest the crank-pin. The stress in the shaft was 8,500 pounds per square inch, and the life 123 million revolutions.

When speaking of crank-pins, I referred to the effect of scratches or skin cracks upon steel, and I want to illustrate this point. Fig. 29 shows the crank-shaft of a pair of McNaughted beam-engines running at 32½ revolutions per minute. After the shaft had worked 9 years, a very interesting crack appeared in one of the necks, as shown in Fig. 29. For a length of 5½ inches, it was absolutely straight, without the jagged edges a crack usually presents, and followed the line of a circumferential scratch, such as might have been made by a knife held against the revolving shaft. At either end it branched off diagonally for a length of 2½ inches, each extension having the normal appearance of a crack. I marked it with a center-punch, and let the engine run on. It ran for 4 months, and then the crack began to extend so rapidly that the shaft was thought to be unsafe, and was replaced. The stress on the neck was about 7,500 pounds per square inch, and the life of the shaft only 51½ million revolutions.

Fig. 30 shows a piece cut from the neck of a steel shaft, after the shaft had been broken by a tup. The shaft was probably new in 1893. The neck was 13½ inches in diameter and 26 inches long. Test-pieces cut from the broken shaft gave a tensile strength of 25.7 tons per square inch, a yield-point of 14.3 tons per square inch, an elongation of 40½ per cent in 2 inches, and a contraction of area of 60.3 per cent. In 1905, the neck was free from cracks, but in 1908, when the next examination was made, there were a number of fine marks like scratches, principally in a circumferential direction, as clean as if cut with a knife. One in particular, about 7 inches from the fly-wheel end of the neck, was 18 inches long. As the marks were so fine and clean, it was hoped that they were nothing more than scratches, or, at most, skin cracks brought out by heating, and as the shaft was very lightly stressed, only about 4,500 pounds per square inch, it was allowed to run on. A few days later, however, the engine had to be stopped, as black oil appeared inside the bore. The long crack was then found to have extended almost continuously round the neck, following one or other of the circumferential scratches. Fig. 31 shows a piece broken off the shaft and magnified about 4 times, which clearly shows how the small surface scratches were eating into the steel. The cause of the scratches could not be ascertained.

Spur Gearing.—About 1879, when horizontal engines of 800 to 1,200 indicated horse-power began to replace beam-engines of half that power in cotton-mills, when pitch-line speeds were rising from 1,800 feet to 2,300 feet per minute, loads on teeth from 10,000 pounds to 18,000 pounds, and gear ratios from 2¼ to 1 to 3 or 3½ to 1, an epidemic of breakages of spur-gear set in. Some 20 per cent of the engine breakdowns were breakages of spur-wheels on engine crank-shafts, and the pinions driven by these wheels broke almost as frequently. Many of these breakdowns were due to irregularities of pitch, twisted teeth, sinuosities of pitch circles, concentration of pressure on the end of teeth through movement of the crank-shaft, back-lash from the momentum of rope-drums on second-motion shafts, and other faults of workmanship and use common to old-pattern molded wheels and to old engines. But the damage was not confined to these. Many new wheels, as good as mechanical skill could make them, with teeth molded by machinery, spur-runs cast in complete circles, and machined internally, carried on crank-shafts held in pedestals, with brasses adjustable horizontally as well as vertically, broke also.

These breakages were usually attributed to "vibration," "wear and tear," "teeth bearing up to points," and similar effects of a cause ignored or not discerned. That cause, in my opinion, was the use of teeth too long and too wide to "correspond with their environment," the most important fact of that "environment" being the unavoidable motion of the engine crank-shafts on which the driving-wheels were hung.

I will try with aid of Figs. 32 to 35 to make this clear. Fig. 32 represents 3 teeth *A*, *B*, *C* of a spur-wheel geared with 3 teeth *D*, *E*, *F* of a pinion. The teeth are supposed to be cycloidal, for involute teeth have not found favor with makers of main driving gear. Their length is exaggerated to make this illustration clear. Similar profiles can be set out, according to the rules in the books, to provide 3 points of contact x, y, z, and 3 teeth to carry the load. They look very pretty upon paper, but they will not work if the spur-wheel *A*, *B*, *C* be forced toward the pinion *D*, *E*, *F* by the motion of the shaft. The contact at y ceases. The pressure is taken off *B* and concentrated upon the points of the teeth *C* and *D*, and there intensified enormously by the forcible retardation of the driving-wheel or acceleration of the pinion. And even if the crank-shaft could be held absolutely steady, the same effect might be produced if the teeth came from the mold full at the points, or if the pitch-line had proud places, both common defects in uncut wheels. If, however, the faces of the teeth were cut away sufficiently to limit the contact to the immediate neighborhood of the pitch-point y, the motion of the wheel toward the pinion would simply cause the tooth *B* to slide on *E* without strain or change of angular velocity. And of all intermediate positions of the point of contact it may be said that the farther it moves from the pitch-point the more destructive become the effects of shaft displacements, incorrect tooth forms, or sinuosities of pitch lines, and conversely the shorter the path of contact the less the mischief resulting from these unavoidable irregularities. Experience has led millwrights to the same conclusion, for they invariably set out wheel teeth so fine at the points and roots that they bear on only near the pitch line when new, and when through wear the bright bearing surfaces extend to the points of the teeth, they chip the points to avert the damage which we have just referred to.

The question is, why do they leave surfaces which are not used when the teeth are new and which have to be chipped off when the teeth are old? I never could get a satisfactory answer. Neither, as far as I know, would wheelmakers cut short their teeth till 1888, when a firm of engineers consented to make a pair of wheels with short teeth, Fig. 33, for their own shop engine. These wheels must have felt like the first lady who appeared in public minus a crinoline, so greatly did they differ from the fashion of their day. They had 49 and 47 teeth 2⅝-inch pitch, 15/16-inch long and 4½ inches wide, the ratio of length to pitch being 0.36. With fixed centers and accurate molding teeth ¼-inch long would have kept contact. These wheels held their grease well and ran smoothly till the engine was replaced in 1892. They were but small, and running at a low speed (1,080 feet per minute), but they were more convincing than arguments or drawings, because they were made of cast iron and could be seen at work.

Figs. 34 and 35 show what they accomplished in a few months. The former shows the teeth of a wheel and pinion put in in November, 1888, after two other sets of gearing had been destroyed in the space of 11 years. The teeth were 4 13/16-inch pitch, 3¾ inches long, and 19 inches wide, while the distance between the centers of the shaft-bearings was only 66½ inches. With these dimensions and a pitch-line speed of 2,410 feet per minute, the motion of the crank-shaft threw the whole load of 16,400 pounds upon the corners of the teeth, and drove the points of the pinion-teeth into the flanks of the wheel-teeth with jar and vibration sufficient to break one of the segments in the following March. Then more teeth were cracked and more segments broken, and it became necessary to replace the entire rim. The new rim was made of steel, with teeth of the same pitch and breadth as the old, but 2 5/16 inches instead of 3¾ inches long, Fig. 35. They would have been better 1½ inches long. The tooth of an engine driving-wheel is a cantilever whose strength varies not as $\text{pitch}^2 \times \text{width} \div \text{length}$, but as $\text{pitch} \div \text{length}$, because, with a short and moving crank-shaft, very little, if any, strength is gained by making the width of a tooth more than one pitch. Thus a reduction of length to 1½ inches would have permitted a reduction of pitch to 3¼ inches, an increase in the number of teeth in both wheels, a shortening of the necessary path of contact, and, if three pitches be considered a sufficient width for the teeth of one engine driving-wheel, as I think it is, less concentration of pressure on the corners from the lifting of the shaft.

Some people consider double-helical teeth stronger than straight teeth. This is a delusion. Width for width of wheel-face, they are much weaker, because, owing to the lifting and end-long motion of crank-shafts, the pressure never acts on both treads at the same time unless provision be made for allowing the pinion-shaft to move end-ways, and even then the force required to overcome the inertia of the pinion, and its shaft, adds seriously to the pressure on the teeth. There is another cause of destructive vibration—namely, irregularity of pitch and inequality of pitch of wheel and pinion. The first is seldom important in machine-molded wheels, and can generally be rendered innocuous by chipping and filing. The second, depending upon the contraction of the castings, can only be remedied by gearing the wheels more or less deeply than was intended by the designer. In my opinion, both wheels of a pair should have pitch circles turned on both sides of the rims, with radii proportional to the number of teeth in each, whether they be the radii marked on the drawing or not. The wheels should be geared to these circles and kept there. The change of the position of the pitch-point on the profile will not materially affect the velocity ratio if the teeth be short. The fashionable length of teeth is now 0.45 to 0.55 of the pitch, instead of 0.66 to 0.75 as formerly, and it might be reduced still more with advantage in many cases.

I should like to have said something about the breakages of spur-wheels other than breakages of teeth, but as most of the breakdowns of these wheels originate in the teeth, it seemed best to devote the time available exclusively to them. The breakages of spur-gearings are now 10 per cent of the total breakdowns. The reduction in the percentage from 20 to 10 is principally due to the supersession of gearing by ropes. The improvements in design and workmanship have done little more than enable wheels to live under conditions which the old wheels could not have faced. But they have done something, and the substitution of steel for iron, of cut or milled for molded teeth, and of shorter teeth and correspondingly finer pitches, will do a little more, but I doubt if it will ever be possible to transmit more than, say, 1,200 horse-power from the crank-shaft of a steam-engine by spur-gearing.

I have now touched briefly, I could not do more, on the principal breakages of most of the important parts of a steam-engine except the beams, gudgeons and parallel motions, and other parts peculiar to beam-engines; and as these are becoming obsolete, I have left them out. I will, however, conclude with an anecdote relating to a

beam-engine. Beams, "walking beams" as they are sometimes called, are usually broken by water in the cylinder or some other extraneous cause, but sometimes they fail gradually from old age, the signs of failure being the appearance of small cracks sometimes in the flanges, sometimes in the webs. A beam in northeast Lancashire began to develop such cracks; they were pointed out to the owner of the engine, their import was explained to him, and he was advised to replace the beam. After listening attentively and in silence to the explanation, he got up, put on his hat, and said: "Mister, them cracks be nowt; I shan't put in no new beam. Why't has nowt to do but wag up and doon."

The Moon's Influence on the Earth's Magnetism*

By S. Chapman, Chief Assistant at the Royal Observatory, Greenwich

SCHUSTER has proved that the varying field which causes the ordinary daily changes in the magnetic elements is produced by electric currents flowing mainly above the earth's surface, and located in the rarefied upper strata of the atmosphere, perhaps where the Auroræ have their origin. The air is rendered electrically conducting in these tenuous regions presumably by the ultra-violet radiation from the sun. The electromotive forces which impel the currents are supposed to be produced by the motions of the air, as indicated by the barometric variation, across the earth's *permanent* field of magnetic force. A not unreasonable value for the electric conductivity of the atmosphere was indicated by Schuster's calculations, based on his theory.

If the atmosphere oscillates similarly in all layers, from the relative amplitudes of the 24 and 12 hourly terms in the barometric variation, it is possible to calculate the relative amplitudes of the corresponding terms in the magnetic variation, provided that the electric conductivity is constant throughout the day and night. There is a fairly large discrepancy revealed between the ratio thus calculated and the observed ratio of the diurnal and semi-diurnal components of the magnetic variation. This points to error in either or both of the assumptions mentioned, viz., that the atmosphere oscillates similarly in all layers and that the electrical conductivity of the air is constant. The latter is almost sure to be incorrect—as Schuster remarks, the conductivity probably falls to a low value at night. On this assumption the theory and observation can be reconciled much more closely, but there still remains the uncertainty as to whether the amplitudes of the 24 and 12 hourly oscillations of the atmosphere preserve the same ratio one to another at all levels.

The moon also influences both the barometer and the earth's magnetic field—the former by the production of a simple semi-diurnal gravitational tide. Both effects are of minute amount, and therefore laborious to evaluate from the observations, but otherwise there is no difficulty in discussing them. It is natural to suppose that the connection between the lunar-diurnal variations at atmospheric pressure and of magnetic force is similar to that between the corresponding solar-diurnal variations, and this is borne out by many features of the lunar-diurnal variations, as, for instance, that the magnetic variations are greater at times of perigee than at apogee—there being some evidence, moreover, that the ratio of the amplitudes at the two periods is equal to the ratio of the corresponding values of the moon's tide-producing force. Again, when the lunar-magnetic variation is determined as the mean from a number of whole lunar months, it should be of the same simple semi-diurnal type with the lunar barometric variation; for although the electrical conductivity of the upper air is a function of the solar time—and therefore also of the lunar time, at any particular phase of the moon—in the mean of one or more whole lunar months (during which time each solar hour will have occurred equally often at all lunar hours) the electrical conductivity of the upper air is a constant as regards lunar time. Thus the semi-diurnal atmospheric oscillation due to the moon must produce a corresponding purely semi-diurnal magnetic variation in the mean of a month; this is what is actually observed.

But, as already hinted, *at any particular phase of the moon* the effect of the variable electrical conductivity of the upper air, in conjunction with the simple semi-diurnal atmospheric oscillation, should be to produce magnetic variations, not only of frequency 2 periods per day, but also of frequencies 1, 3, 4, etc. This the author has actually found to be the case, and it appeared further that the epochs of the various components undergo regular changes during the course of the lunar month, the change of epoch per month for the components of frequencies 1, 2, 3, 4, being respectively -2π, o, 2π, 4π. At new moon, when the sun and moon are on the same meridian, the epochs of all the components are nearly equal. The changes of epoch throughout the month clearly result in the disappearance from the variation for the mean of the whole month of all components except the second, which is of constant epoch. These changes with the position of the sun greatly confirm the hypothesis of a variation in the electrical conductivity of the upper air, depending on the solar hour angle.

The author has also proved mathematically[1] that the law of change of the epochs of the various components during the course of the month is precisely what was to be expected from the combination of a semi-diurnal atmospheric oscillation depending on lunar time and a variable conductivity depending on solar time. In fact, the change of epoch per month of the component of the magnetic variation, of frequency n, is $2(n-2)\pi$, which is verified (*loc. cit.*) from the observations for $n=1$ to $n=4$. A consideration of the amplitudes of the several harmonic components in the magnetic variation will, moreover, when sufficiently good material is available, enable the dependence of the atmospheric conductivity upon solar time to be determined; a beginning has already been made with this work. The investigation is possible with the lunar-magnetic variation, and not with the solar-diurnal magnetic variations, because in the former case, unlike the latter, the atmospheric oscillation which is responsible for the magnetic effect is of *a single period* (12 hours), so that any other periodic terms appearing in the magnetic variation must be due solely to the variable electrical conductivity of the air. When the law of change of the latter has been evaluated from the lunar-magnetic variations, it may be possible to work back from the solar-diurnal magnetic changes and to determine the relative amplitude of the atmospheric oscillations on which they depend; thus the similarity of atmospheric oscillations at widely different levels might be tested.

A natural test to apply to this theory of the lunar-diurnal magnetic variations is the examination of their dependence on sun-spottedness. The solar-diurnal magnetic variations show a marked periodicity in amplitude, corresponding to the sun-spot periodicity, and this points, on Schuster's theory, to a corresponding change in the electrical conductivity of the upper air. This should affect the lunar-diurnal variations in a similar way. Different opinions have been held as to whether or not the observations do show this. The uncertainty is due mainly to the large accidental error in the variations as determined from a single year's observations. In the curve accompanying this abstract all the evidence upon the point which is at present available is summarized; unfortunately it does not suffice to settle the question at issue.

* Abstract of a paper read before the British Association for the Advancement of Science, in Birmingham, September 15th, 1913, published in *Terrestrial Magnetism.*

[1] On the diurnal variations of the Earth's Magnetism produced by the Moon and Sun, *Phil. Trans.*, A. 213, pp. 279-321.

An Orchid With Explosive Flowers

DR. H. N. RIDLEY ("Straits Settlements Gardens Bulletin," vol. i., 1913, pp. 191-3) describes an orchid from Sarawak which shows a remarkable floral mechanism. This species (*Plocoglottis porphyrophylla*) is widely distributed in Malaya; but, being inconspicuous and a lover of deep shade, is but little known. It bears only one flower open at a time, but remains in flower for over three months, producing a fresh flower every few days until the raceme is more than two feet long and has borne about fifty flowers. Unfortunately, the author's account is not accompanied by illustrations, but the following description may be followed if the reader examines any ordinary orchid flower. In the young flower the ovary begins to twist, as usual in orchids, until it has overtopped the bract; it carries the swelling bud through about 75 degrees and then stops twisting. During this twisting the dorsal sepal outgrows the other two sepals, and pushes over the apex of the bud. All the sepals at this stage are similarly narrowly ovate, the lateral ones asymmetrically so. The lateral petals are linear, and curved round the column to meet at their tips. The lip is about as broad as long, cuspidate above its broad shoulders, with the margins in the lower part frilled and turned under; if these margins are uncurved, it is seen that they are the lateral lobes of the lip. Under each broad shoulder a wart has begun to form.

Between this stage of the bud and maturity the following changes occur: The contiguous halves of the lateral sepals thicken from the middle upward; the cuspidate tip of the lip turns back, its shoulders enlarge, and the warts become sharp little upstanding cones, while the side lobes increase along their margins so that they are too full for the space they have, and toward the base of the lip tend to form an upstanding rounded crest. Two very fleshy staminodes lie within the curve of this crest, one on each side. In opening, which occurs in late afternoon or early evening, a slit appears between the lateral sepals; then these sepals break away and slowly take up a position at right angles to the ovary, and their thickened areas become convex inward and throw the thin parts back; then the lateral petals rapidly elongate, curving over strongly, so that their points pass between the bases of the lateral sepals, and in this curious action they deflect the lip on to its base holding it down against a certain amount of resistance in contact with the lateral sepals. Thus the flower gapes somewhat. During the night the dorsal sepal turns back and the lateral petals straighten. The upper lateral sepal no longer held away from its fellows by the lateral petals now moves down to be in contact with it and is thus almost median as regards the lip, and as the lateral sepals move away the lip is caught against its convex swelling and held folded down as the lateral petals placed it. A touch now frees the lip and causes it to spring up against the column.

It is apparently fertilized by rather small insects, which, attracted to the flower, are trapped by the up-springing of the lip against the column, and, in struggling to free themselves, effect pollination. The mechanism is very curious; the lip is a trigger put into place by the lateral petals, and held there by one of the lateral sepals. This alone makes it of unusual interest, but this is heightened by the angle at which the flower stands, by the movement out of the median line of the column and by the movement toward it of a lateral sepal. The flower has apparently no scent and no free honey; its colors are lemon-yellow to yellowish-green, with deep crimson markings on the lip and the swollen parts of the lateral sepals are maroon.—*Knowledge.*

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The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents

PAGE

Improvements in Radiotelegraphy and Radiotelephony.—II.—By W. H. Eccles.—20 illustrations.......... 354
Rose Growing Industry of Lyons, The.......... 355
South America as an Export Field.......... 355
Hairs and Hair-Pigments.—By H. Onslow.—6 illustrations 356
Legal Time in Various Countries, The.—By Dr. M. Philippot.—1 illustration 357
Insulation for Cold Storage.—By Prof. Henry Payne.—2 illustrations 359
Important Austrian Mining and Iron Works, An.—By J. A. Seager.—11 illustrations.......... 360
Development of the Aeroplane, The.—I.—By Dr. R. T. Glazebrook.—13 illustrations 361
Breakdowns of Stationary Engines.—By Michael Longridge.—35 illustrations 364
Moon's Influence on the Earth's Magnetism, The.—By S. Chapman 368
An Orchid with Explosive Flowers.......... 368

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AGE
454
455
455
456
457
459
460
461
464
468